

THE QUALITY ATTRIBUTES OF SOUTH AFRICAN RABBIT MEAT AND CONSUMER ATTITUDES TOWARDS IT

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature

Date

ABSTRACT

Meat processing industries in South Africa are faced with the challenge to produce a variety of white meats. This is due to the fact that consumers tend to consume less red meat and more chicken and pork that are perceived to be healthier due to the negative publicity surrounding red meat and health. The nutritional emphasis is on leaner carcasses and an increase in the consumption of polyunsaturated fatty acids while reducing the ratio of n-6:n-3 polyunsaturated fats in the diet. Another way in which this can be achieved is through introducing rabbit meat which has low fat, low cholesterol content and high protein content, while displaying a positive fatty acid profile. Carcass quality and meat quality in rabbits may to a large extent be affected by age of slaughter and type of breed.

This study had a dual purpose. Firstly it aimed at quantifying the effects of breed and age on parameters pertaining to carcass quality and meat quality of commercial rabbits, namely California breed and hybrid (California x Dutch red). Secondly, to determine the differences between ethnic groups on their perceptions towards rabbit meat, thereby providing information on its marketing potential.

To accomplish the first objective 50 rabbits from the two breeds were housed in individual cages, weighed on weekly basis and fed *ad libitum*. The rabbits were slaughtered at 9, 11, 13, 15 and 17 weeks of age (n=5 from each breed). For the second objective the perceptions of three ethnic groups on factors affecting consumers' choice of rabbit meat were determined through a structured questionnaire. The questionnaire was tested for validity beforehand.

There was no significant difference between the two breeds regarding body weight, feed intake, carcass weight and drip loss. The California breed had a higher dressing percentage (53.7%) and meat yield (29.2%) compared to the hybrid (52.5% and 27.5% respectively). Age treatments showed a highly significant difference on all parameters investigated. Increasing the age proportionately increased the amount of fat, while the moisture content decreased. The California breed exhibited higher percentages of fat compared to the hybrid at all ages of treatment. California breed contained more phosphorus, magnesium and zinc as opposed to the hybrid, the only exception being copper, where the hybrid had higher concentrations.

The total fatty acid (169.2 mg/100 g) of the California breed was higher than that of the hybrid (133.5 mg/100 g). As a result there were more saturated fatty acids (55.4 mg/100 g) and monounsaturated fatty acids (62.3 mg/100 g) in the California breed than in the hybrid (44.2 and 45.6 mg/100 g respectively). Both breeds had 67% unsaturated fatty acids. Although there was no significant difference between the P:S ratio of the two rabbit breeds, the values obtained were higher (+0.9) than the value of 0.7. This is an indication that the rabbit meat contains a P:S ratio that could be considered very desirable. The n-6:n-3 ratio for both breeds were high (11.6 for California and 12.7 for hybrid). The cholesterol and amino acid profile of the two breeds were not affected by the type of breed.

The consumer survey indicated that 52% (n=158) of respondents had never eaten rabbit meat before due to reasons such as scarcity, lack of knowledge about the meat, associating rabbits with pets and

cultural constraints. Nevertheless, 57% of these people were optimistic about eating rabbit meat. In addition, having eaten rabbit meat before seemed to contribute positively towards acceptance of rabbit meat.

Generally, respondents preferred purchasing rabbit meat in portions as opposed to live or whole carcasses. Their decision to purchase rabbit meat was firstly driven by price, thereafter freshness, leanness and tenderness of meat. The respondents expect to buy rabbit meat at a price lower than that of chicken.

Rabbit meat contained low sodium and high proportion polyunsaturated fatty acids-some of the most important food attributes required to maintain and improve health. However, most of the respondents in this study were not familiar with the positive attributes of rabbit meat and need to be taught the benefits of this product.

OPSOMMING

In Suid Afrika is daar 'n uitdaging vir die vleisproduserende voedselindustrie om 'n verskeidenheid witvleis te bemark. Dit word toegeskryf aan die feit dat verbruikers minder rooi vleis as hoender en vark eet wat as meer gesond beskou word weens die negatiewe publisiteit wat geassosieer word met rooivleis en gesondheid. Die voedingsfokus is op maerder karkasse, groter inname van poli-onversadigde vetsure, en 'n vermindering in die verhouding n-6:n-3 poli-onversadigde vetsure in die dieet. Een van die maniere waarop dit gedoen kan word, is die bekendstelling van konynvleis wat gekenmerk word deur lae vetinhoud, lae cholesterolinhoud en 'n hoë proteïeninhoud, en 'n positiewe vetsuurprofiel. Karkas- en vleiskwaliteit van konyne word tot 'n groot mate geaffekteer deur ouderdom van slagting en die ras.

Hierdie studie het 'n tweeledige doel. Eerstens mik dit na die kwantifisering van die effek van ras en ouderdom op die parameters wat met karkas- en vleiskwaliteit van die Kaliforniese ras en die kruisgeteelde ras (Kaliforniese X Hollandse rooi) verband hou. Tweedens, om die verskille in etniese groepe vas te stel met betrekking tot hulle persepsies van die faktore wat hulle keuse van konynvleis beïnvloed, en op dié wyse inligting te verkry tov die bemarkingspotensiaal daarvan.

Om in die eerste doelwit te slaag is 50 konyne van die twee rasse in individuele hokke gehuisves, op 'n weeklikse basis geweeg en *ad libitum* gevoer. Die konyne was geslag op 9, 11, 13, 15 en 17 weke (n=5 vir elke ras). Vir die tweede doelwit, is die persepsies van drie etniese groepe oor die faktore wat die verbruikerskeuse van konynvleis kan bepaal, mbv 'n gestruktureerde vraelys bepaal. Die vraelys is vooraf vir geldigheid evalueer.

Daar was geen beduidende verskil tussen die twee rasse wat betref liggaamsmassa, voedselinname, karkasgewig en dripverlies nie. Die Kaliforniese ras het 'n hoër uitslag-persentasie (53.7%) en vleisopbrengs (29,2%) in vergelyking met die kruisgeteelde ras (52.5% en 27.5% respektiewelik) gehad. Ouderdom het hoogsbeduidende verskille op al die parameters wat ondersoek was, getoon. Die toename in ouderdom was gepaardgaande met proporsionele toename in karkasvet en afname in vog. Die Kaliforniese ras het, by alle ouderdomsbehandelings, in vergelyking met die kruisgeteelde ras, 'n hoër persentasie vet opgelewer. Die Kaliforniese ras het teenoor die kruisgeteelde ras hoër fosfor, magnesium en sink bevat. Die uitsondering was koper waar die kruisgeteelde ras 'n hoër waarde gehad het.

Die totale vetsure vir die Kaliforniese ras (169.2 mg/100 g) was hoër as vir die kruisgeteelde ras (133.5 mg/100 g). Om dié rede was daar in die Kaliforniese ras meer versadigde vetsure (55.4 mg/100 g) en monoönversadigde vetsure (62.3 mg/100 g) as vir die kruisgeteelde ras (44.2 mg/100 g en 45.6 mg/100g onderskeidelik). Beide rasse het 67% onversadigde vetsure gehad. Hoewel daar geen beduidende verskille was in die polionversadigde:versadigde (P:V) verhouding nie, was die waardes hoër (+0.9) as die 0.7 wat aanbeveel word. Die n-6:n-3 verhouding vir beide rasse was hoog. (11.6 vir die Kaliforniese ras en 12.7 vir die kruisgeteelde ras). Die cholesterol- en die aminosuurprofiel was nie deur die ras beïnvloed nie.

Die verbruikersnavorsing het getoon dat 52% (n=158) van die respondente om verskeie redes nog nie konynvleis geëet het nie, weens redes soos onverkrygbaarheid, gebrekkige kennis van die vleis, die assosiasie van konyne met troeteldiere en kulturele beperkinge. Desnieteenstaande is daar 57% van die respondente wat optimisties is oor die eet van konynvleis. Die eet van konynvleis by vorige geleenthede het bygedra tot die positiewe aanvaarding van konynvleis.

Oor die algemeen het die respondente verkies om konynvleis in porsies te koop, in plaas van lewendig of heel karkasse. Die besluit om konynvleis te koop, is hoofsaaklik gedryf deur prys, daarna deur varsheid, maerheid en sagtheid van die vleis. Die respondente verwag dat die prys vir konynvleis laer sal wees as vir hoender.

Konynvleis bevat lae natrium en 'n hoë verhouding poli-onversadigde vetsure - van die mees belangrike voedingeienskappe om gesondheid te handhaaf en te verbeter. Ongelukkig was meeste van die respondente in hierdie studie nie vertrouwd met die positiewe eienskappe van konynvleis nie, en moet hulle geleer word deur middel van omvattende bemarkingsaksies van die voordele van hierdie produk.

DEDICATIONS

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CHAPTER 1

Introductory perspectives

1.1 Introduction

Meat consumption is generally considered as a status symbol due to its high nutritional value and price. As a result, consumers in higher income groups tend to spend a larger share of their food expenses on meat (Manojkumar, 2002). The main constituents of meat are water and essential nutrients such as high-biological-value protein, fat, minerals and vitamins, which play an important role in achieving a balanced diet for human health (Weber & Antipatis, 2001). Apart from its nutritive value, meat consumption is increased by its appealing flavour, texture and appearance factors which are considered very important sensory attributes used by consumers to judge meat quality (Warriss, 2000).

In recent years the meat industry has come under increasing scrutiny because of concerns such as those relating to kilojoules, saturated fat, cholesterol and heart disease (Higgs, 2000). This concern is reflected in the reduced consumption of red meats (Charlet & Henneberry, 2002, Manojkumar, 2002). In fact, there is now a greater demand than ever before by consumers for food perceived to be healthy, fresh tasting and more nutritious (Beitz, 1997, Sloan 1999, Uccella, 2001, Mermelstein, 2002). According to Sloan (1999) today's shoppers continue to pursue an aggressive dual strategy for managing their health through foods. Recent research shows that 81% of consumers select foods that offer health benefits such as 'high in calcium', or 'cholesterol-lowering properties' and 78% are also cognizant of avoiding undesirable ingredients, selecting products that are lower in fat, and have a low kilojoule value (Wood & Fisher, 1990). Meat industries are therefore, challenged to work towards increased convenience in foods by producing lean meat products as consumers tend to spend a lot of time removing fat for the development of dishes (Higgs, 2000).

In view of all these recent perspectives on meat consumption, rabbit meat could be a very suitable food to meet the consumers' demands (Brown, 2002). It is one of the easiest meats to produce, showing good characteristics for production in that these animals have a high growth rate, a high feed efficiency, an early marketing age, and require a small production area (Onifade, Obiyan, Onipede, Adejumo, Abu, & Babatunde, 1999). These facts suggest that rabbit has a good potential as a livestock species in large-scale production. The rabbit is superior to most other livestock in its breeding and meat-producing performance. A single doe can produce up to 100 offspring a year, which in turn can gain weight at the rate of 40 grams a day. Young rabbits can be marketed when they are around 8-10 weeks old (FAO, 1999).

Apart from their production potential rabbit meat is a mild all white meat with a unique delicate flavour (Fowler, 1986). Rabbits produce a highly nutritious meat which is relatively higher in protein and

polyunsaturated fatty acids, while lower in the undesirable fatty acids, total fat, cholesterol content, having a lower kilojoule content as well as low sodium levels (Hernandez, Pla, Oliver, & Blasco, 1999, Corino et al., 1998). The low cholesterol content of rabbit meat is attributed to the fact that as the number of muscle fibres increases the cholesterol levels also increase, resulting in the tendency for the level to be higher in the more red muscles (Higgs, 2000). According to Brown (2002), rabbit meat is easy to digest and some physicians recommend it for their patients who have trouble eating other meats and those that are on special diets, such as patients with heart disease, diets for the aged, low sodium diets, weight-reduction diets and weight-management diets.

According to previous research (Onifade et al., 1999, Hernandez et al., 1999, Dalle Zotte, 2002) it is evident that the greater productivity of rabbits, the quality of meat and its nutritive value depends on the feed formulation. Moreover, feed is the single largest operating expense in rabbit production. Sell and Aakre (2002) and Schoenian (2002) asserted that feed costs often represent 75% of total operating expenses, but to save costs feed should be purchased in bulk. They say commercial pellets generally meet all of the rabbit's nutritional requirements and can be purchased at any feed store. Lawrie (1998) asserted that animals on different treatments of nutrition, whether they are from the same breed or weight, will differ significantly in form and composition. Forrest, Aberke, Hedricl, Judge and Merkel (1975) reports that the ability of animals raised for meat consumption to convert the feed that they consume into meat is directly related to the level of feed intake. Those rabbits that are fed *ad libitum* are usually more efficient in converting feed to edible meat than are limited fed animals (Xiccato, Trocino, Sartori & Queaque, 2002).

Despite the general impression of rabbits as pets, Baldo (cited by Billet, 1992) predicts an increased demand of rabbit meat in South Africa. At present, there are already a large number of consumers for rabbit meat in the country, especially black South Africans. This number is further increased by Portuguese families residing in the Pretoria-Witwatersrand and Vereeniging (PWV) area. Moreover, McCracken (1994) stated that the meat consumption rate in South Africa is steadily increasing as black consumers grow, more affluent. Some African countries (Ivory Coast, Democratic Republic of Congo, Zambia, and Mozambique) have expressed their interest to buy rabbit meat from South Africa. There are also possibilities for exports to Namibia and Angola, due to a large number of Portuguese settlers in these countries. In fact, South Africa has an advantage over other African countries for rabbit breeding, mainly because of its suitable climate (Green, 1996, Billet, 1999).

According to Gittens (2000) the Ciskei Rabbit Production Corporation was established in an attempt to promote small-scale farming for an affordable meat in the Eastern Cape. This project was considered appropriate for poor people in the rural areas as it contributes in increasing the family income while providing high quality meat at low cost. However, rabbit meat is not common in South Africa. Therefore, most people are still reluctant to support the rabbit-meat production projects.

Apart from lack of knowledge about rabbit meat, food habits are a component of culture that has significant influence on the food decisions consumers make. Culture determines how people use a certain

food and ultimately affects the intake of that food (Asp, 1999). With regard to rabbit meat, Dalle Zotte (2002) points out that its consumption relies heavily on cultural, traditional and religious beliefs. Sonandi, Masika and Van Averbek (1996) found that there are African beliefs which forbid the consumption of rabbit meat. These beliefs are associated with the pelt colour of the rabbits. In addition to that, Lukefahr and Cheeke (1990) noted that the diminishing bush-meat industry has made a significant contribution to small-scale farming in many developing countries.

Although few studies for evaluating small-scale rabbit production have been conducted in South Africa (Sonandi et al., 1996), no report is available in the literature pertaining to growth rate, the physical meat quality of different rabbit breeds, the chemical composition and carcass yield. Therefore the information on the choice of breed is of great importance to a commercial breeder. It creates an awareness of all the necessary traits that should be considered for rabbit meat production that will yield high nutritional value and produce the greatest amount of profit. Commercial traits typical of a good meat rabbit are rapid growth rate, first-class carcass conformation, fast maturation, good feed conversion, large litter size and good mothering ability (Green, 1996).

Besides, the effect of breeds on the overall quality of rabbit meat, little work has been done on the effect of slaughter age on overall quality. This knowledge is needed to substantiate the concept that delaying the age of slaughter improves the eating quality of rabbit meat. Presently rabbit meat is not considered to be sufficiently tasty. Delaying the slaughter age will also help for better control of meat quality and efficiency of production, in that the higher cost of production could be counterbalanced by the higher sales prices granted to a product with improved technical eating qualities (Gondret, Mourot & Bonneau, 1997).

1.2 Aims

The aims of this research were to investigate the effect of two breeds on the growth rate and the overall quality of rabbit meat. The age-related pattern of slaughter was also established to assess differences in their final carcass characteristics and nutrient composition.

These facts are of great importance to the breeder who must have a wise choice in selecting and buying suitable breeding stock because attaining high profits, maximum benefit of nutrition, growth rate and overall quality of meat lies in the healthiness and fast growing progeny that are determined by the parent stock. The breeder will also gain better understanding on the differences brought about by slaughter age on meat quality.

The specific objectives of the study were:

- To determine the growth performance of two breeds.
- To investigate the feed conversion ratio of the two breeds.
- To compare the two rabbit breeds on carcass yield parameters.

- To compare the two breeds with regard to the proximate chemical analysis of raw meat: moisture, fat, protein and ash (AOAC, 1997).
- To determine the effect of age at slaughter on the chemical composition of rabbit meat.
- To investigate the effects of breed on fatty acids, amino acids and mineral content of rabbit meat.
- To compare the quality of two rabbit breeds in terms of physical meat attributes (Honikel, 1998).
- To investigate the influence of ethnic groups on the perceptions of consumers pertaining to the choice of rabbit meat.
- To investigate the influence of ethnic groups who consume rabbit meat on certain marketing factors that will impact on the potential for marketing rabbit meat in South Africa.

The independent variables of the study for the first set of objectives were therefore rabbit breeds and slaughter age. The dependent variables were growth rate and feed conversion ratio (as established by carcass yield) and physical meat quality traits and proximate chemical 'attributes'. For the second set of objectives, ethnic groups was the independent variable and consumer attitudes and marketing factors the dependent variables. See Figure 1 for a layout of this conceptual framework.

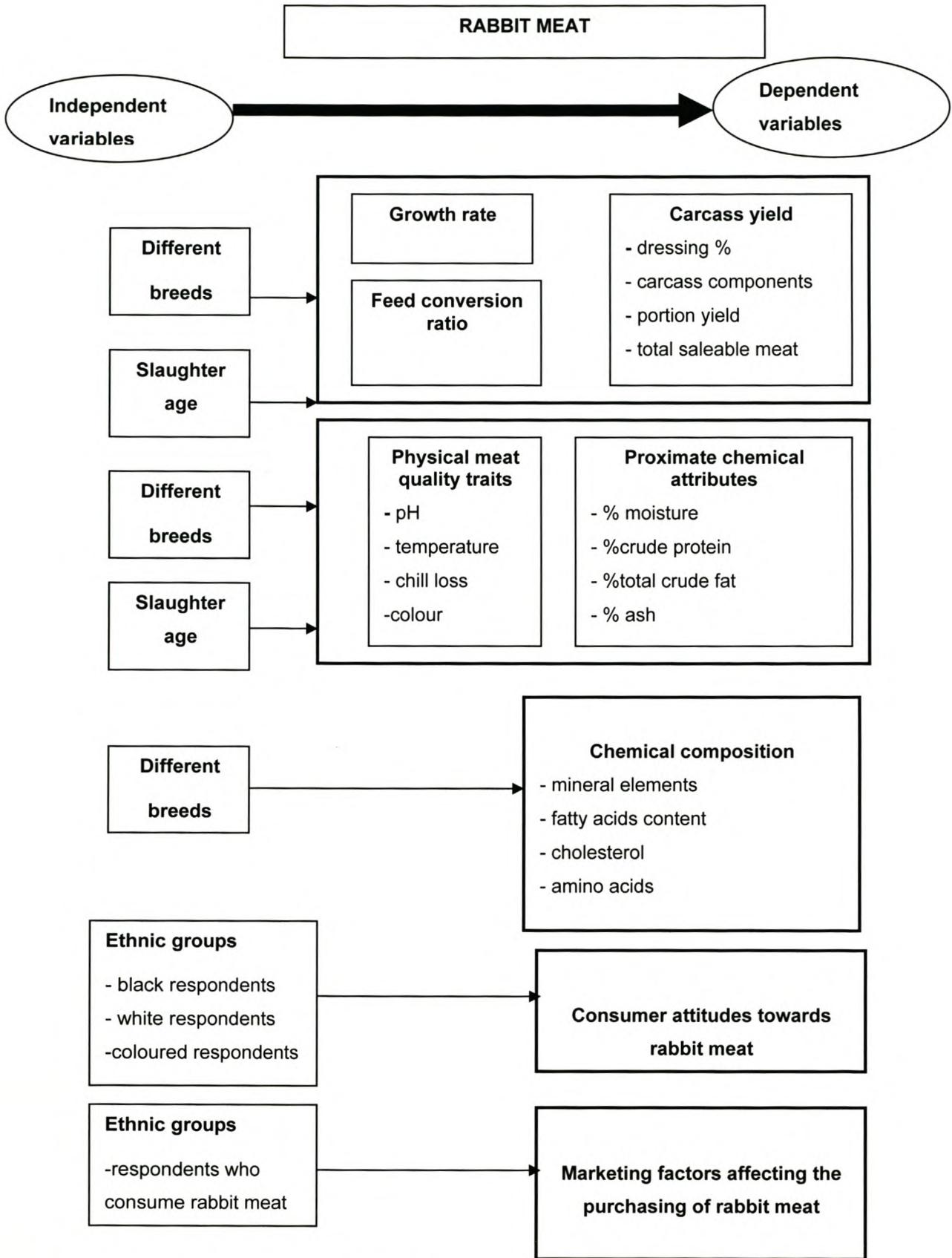


Figure 1 Conceptual framework of the study

1.3 Outline of study

This present chapter gave an introductory perspective on the aims and the outline of specific objectives of the study. Chapter 2 will deal with a review of the literature pertaining to carcass quality and meat quality, while chapter three will deal with a review of the literature on factors driving the food choice of rabbit meat. The first review chapter contains a theoretical background to the research conducted and reported in Chapters Four, Five and Six which pertain to carcass quality and meat quality, while the second review chapter serves as guide for the consumers' research. Chapters Four, Five and Six have been written according to the technical format for the "Meat Science" journal, while Chapters Seven and Eight, which have a consumer's orientation, are written according to guidelines for the Journal of Family Ecology and Consumer Sciences.

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CHAPTER 2

Carcass quality and meat quality

2.1 Introduction

The literature review of this chapter starts with brief definitions of terms used in rabbit breeding followed by a short description of rabbit carcass, meat quality and meat composition. This chapter deals with the factors affecting growth rate of animals. They include feeding and type of breed. It is clearly stated by Ouhayoun (1998) that all factors influencing growth rate lead to changes in carcass quality and meat quality. Main factors that can affect rabbit carcass are explained in this chapter. Discussion on the yield is also included in this review.

2.1.1 Definition of terms

The following are important terms used in rabbit production as stipulated by Schoenian (2002)

Rabbitries – a rabbit-raising enterprise

Doe – female rabbit

Buck – male rabbit

Kindle – delivery of new-born rabbits

Kits – baby rabbits

Fryer – a less than 14-week-old rabbit sold for meat consumption. They are normally marketed at a target age of 56 days but may not attain market weight until 70 days (Arrington & Kelly, 1976, McNitt, 1994).

Roaster – any rabbit over 14 weeks, sold for meat consumption. These are rabbits under the age of 6 months, but have not been sexually active, meaning they have not been used for breeding purposes (Arrington et al., 1976).

Stewer – rabbits over the age of 6 months. They have been sexually active and productive, and are normally tough these rabbits are the same as old hens and roosters (Arrington et al., 1976).

Capons – bucks that have been castrated. To date, there is little market for roaster, stewer and capon rabbits, but that may be changing in the near future (Lamar, 1998).

2.1.2 Descriptions of concepts

2.1.2.1 Meat quality

To succeed in the marketplace of tomorrow, quality must come first and quantity second (Grandin, 2000). According to Northcutt (1997) it is difficult to define quality as quality lies in the eye of the beholder. However, the consumer's perspective of quality is more appropriate because characteristics of a product according to consumer's expectations will determine the sale of the product (Warriss, 2000). Rabbit meat, like all other meat products should exhibit all the functional properties that collectively describe the desirable attributes in a meat product (Dalle Zotte, 2002).

In the case of meat, certain factors such as species, breed, sex, age, pathology, fat content, and diet have a significant influence on the quality of meat. Furthermore, the method used for slaughtering and maturing, cutting, packaging, storage, transport, cooking and serving can all contribute to the overall quality of the ultimate product as perceived by consumers (Mermelstein, 2002, The Meat Academy, 1998). Meat quality is also significantly affected by conditions of animal production in relation to animal welfare, the impact of animal production on the environment and, of course, food safety. Meat quality is reflected by certain properties such as nutritional properties (proteins, lipids and their essential sub-constituents). Sensory properties (tenderness, flavour and colour), health-related properties (fat and fatty acids (FA)), and technological properties (e.g. suitability to be processed) (Dalle Zotte, 2002).

Like all other livestock, rabbit meat products are also evaluated according to meat quality and carcass quality (Dalle Zotte, 2002, Merdji, 2002). However, it is important to note that breeds may differ in meat quality and carcass composition at the same market weight, due to differences in degree of maturity (Kohlen & Ducro, 2002). It is essential to produce a carcass product that satisfies consumers' specification in terms of economic objectives, such as saleable meat yield and attractiveness to the consumer (Dalle Zotte, 2002, Warriss, 2000).

2.1.2.2 Carcass quality

Carcass quality refers to carcass weight, yield of retail-cuts (loin joint: 23 – 28% or hind legs 27-29% of chilled carcass). In addition, meatiness refers to meat:bone ratio of the chilled carcass and it is around 8% as recorded by Green (1999). The lean content is not an important criterion in rabbits because the rabbit is very lean in comparison with other farm animals; it contains 3-6% fat of the carcass (Blasco, Ouhayoun & Masoero, 1992). Rabbit carcass quality mainly concerns carcass weight (varying from 1.0-1.8 kg).. Slaughter yield is around 55-60% of the live weight and chilling losses is about 2.4-4% of the carcass weight (Blasco & Ouhayoun, 1996).

2.1.2.3 Meat composition

Meat is a good source of high-biological value protein. It contains all the essential amino acids for human health (Varnam & Sutherland, 1995). Of the total nitrogen content of muscle, 95% is protein and 5%

smaller peptides and other compounds. According to Warriss (2000) it is also an important source of the B vitamins, particularly B₁ (thiamine), niacin (nicotinic acid), B₂ (riboflavin), B₆ and B₁₂ (cyanocobalamin), and vitamin A (retinol). On top of its protein and vitamin content, meat also supplies the human body with large quantities of lipid. The human body gets its energy from this lipid, especially for people engaged in heavy labour or where overall dietary intake is limited (Varnam et al., 1995). The minerals that are generally contained in meat are iron, copper, zinc and selenium.

Compared with the meat of other species, rabbit meat is richer in proteins, certain vitamins and minerals (Bernadini, Castellini & Lattaioli, 1994). The protein content is higher than that of many kinds of meat and the protein value of domestic rabbit rank higher than any other meat used for human consumption. Besides being rich in the B vitamins and low in fat and cholesterol, its unsaturated fatty acid content is about 63% of the total fatty acids (Gittens, 2000). In addition, Jithendran (2002) says rabbit fat contains less stearic and oleic acids than other species and higher proportions of the essential polyunsaturated fatty acids, linolenic and linoleic fatty acids. According to Lawrie (1998) fat molecules have beneficial effects on human health, in the sense that some monounsaturated fatty acids (i.e. fatty acid with one double bond in the chain of carbon atoms), are protective against heart disease, while the longer chain polyunsaturated fatty acids, particularly those with the first double bond at the omega-3 position, helps to prevent clotting and that conjugated linoleic acid, an isomer of linoleic acid, is protective against cancer, obesity and heart disease.

To summarise the nutritional composition of rabbit meat: 100 g raw rabbit contains 564 kJ and 20 g of protein. The legs and loins have a very low fat content of about 2-3%. The shoulders have some fat on them, which gives them more flavour, but it also increases the fat content to about 7%. Cholesterol is really low - about 55 mg per 100 g. Its amino acids are of high biological value. It is a good source of potassium, phosphorus and magnesium (Dalle Zotte, 2002, Ouhayoun, 1998, Arrington et al., 1976).

Additionally to the nutritional benefits, Green (1996) states that rabbit meat tastes good and looks good. It is easy to cook. Methods used for cooking chicken can also be used for cooking rabbit meat, e.g. roasting, frying, grilling, stewing, casseroles and even boiling.

2.1.2.4 Growth rate

The growth curve of rabbits is the same as for all other domesticated animals. At first the rate of gain increases up to +/- 6 weeks and then it decreases again. One-week-old rabbits grow at 11 g/d while 6-7-week-old rabbits grow at 40 g/d. Rabbits fed on concentrated diets can gain 35-45 g/d and on green fodder 15-30 g/d. Although growth rate decreases after 6 weeks of age, slaughter age is at about 8 weeks. The reason for this is that feed conversion efficiency is high until 8 weeks and thereafter starts to decrease (Fielding, 1991).

Ouhayoun (1998) further stipulates that between 100 g and 2 450 g body weight the muscle:bone ratio of the carcass increases very rapidly and reaches its maximum value. Beyond 2 450 g it tends to decrease.

The increase in the cost of feeding associated with adipogenesis is therefore very high before the muscle:bone ratio has reached its maximum value. The liver proportion increases up to an empty body weight of 1 500 g and then rapidly decreases.

2.2 Factors influencing the growth and development of meat animals

The term 'growth', as used when referring to animals, is an increase in body weight and height of a young animal over a period of time on its way to becoming an adult (Fowler, 1986). It involves change in shape and perhaps composition (Warriss, 2000). At any time growth to a large extent is determined by the balance between the genetic potential of an animal for maximum growth and environmental factors such as adequate nutrition, comfortable housing and other husbandry practices that enhances growth performance (Pond & Pond, 2000). These factors, together with management practices, can influence the ultimate carcass composition of animals. For example, lean, fat and bone percentages generally differ due to effects of growth rate and other factors such as hormonal influences and diet (Lawrie, 1998).

2.2.1 Nutrition

Lawrie (1998) claims that the right kind of food served in the right proportions, is the most important factor that determines the development, dominance and survival of all living organisms. Forrest et al., (1975) supports this view that nutrition governs the actual rate of growth and the extent to which development will be attained. It is possible to control the rate at which different tissues and parts of the body grow and develop by altering the nutritional level of the animal and selecting the time at which the nutritional level is altered. For example, in the experiment conducted by Trocino, Xiccato, Queaque and Sartori (2002), growth performance of rabbits was affected by the dietary starch level. At the end of the trial, rabbits fed high starch diets were heavier compared to rabbits fed low starch diets due to the higher daily weight gain. The growth rates of the animal reflect both differences in digestibility and in feed intake, the latter being mainly determined by the balance of nutrients - especially of protein in relation to energy - for metabolism (Ramchurn, Raggoo & Raggoo, 2000).

Food energy is used for both the maintenance of existing tissues and the growth of new tissue. The maintenance requirement for energy is minimised with fast growth and thus maximum food intake, but maximum food intake, may produce carcasses that are too fat. It may therefore be necessary to maximise growth rate at other stages to produce a compromise between efficiency of growth and desirable carcass fatness (Warriss, 2000).

The rabbit gut is so specialised and eating is so central to the rabbit's life and wellbeing, that key to a healthy rabbit is a healthy diet (Kruse, 2002). Pellet diets are originally formulated as an efficient, economical, and easy-to-use method to promote rapid growth and weight gain in rabbits raised for meat or fur. Rabbits are not meant to live on pellets for very long (Amici, Margarit & Finzi, 2002). The uncontrolled feeding of a pelleted diet to a house rabbit can lead to obesity, heart and liver disease, chronic diarrhoea,

and kidney disease as a result of the high energy value, the low fibre, and high calcium levels in the pellets. However, in South Africa no commercial diets formulated for rabbits are available, most rabbit producers feed calve (cattle) diets (Gittens, 2000).

2.2.2 Water

Water is essential for life and growth. An animal can survive long periods without food, but it cannot survive without water (Forrest et al., 1975).

2.2.3 Hormones

According to Lawrie (1991) hormones are considered to act as regulators in helping to control various chemical reactions concerned with the maintenance and growth of tissues, and other physiological processes. Pond et al. (2000) add that many hormones have growth factors that influence animal growth. Apart from influencing the rate of growth, hormones also affect the chemical composition and efficiency of growth. The pituitary gland situated at the back of the brain is directly responsible for the creation of many hormones that are related to growth in animals. The amount of each hormone produced is regulated by the hypothalamus, a part of the brain situated next to the pituitary gland (Biology Online, 2002).

Recently, several exogenously administered hormones and other metabolites have been shown to improve growth, and in many cases increase muscle growth and decrease fat accretion in growing animals (Pond et al., 2000).

2.2.4 Genetics/Breed

Heredity provides the necessary potential for growth and development, thus the genetic coding of an animal's body determines the way it works, with the external environment either promoting or inhibiting the effectiveness of some of these genes (Wood & Fisher, 1990). According to Lawrie (1998) there is a close relationship between environmental and genetic factors meaning that favourable environmental conditions are necessary for the full expression of the individual's genetic capacity. Forrest et al. (1975) found that the interaction of heredity and environment implies that animals with a certain genotype might perform better in one environment than in another.

Genes are the blueprint of living organisms including animal bodies. They are responsible for the formation of a variety of proteins essential to any organism's survival. These proteins are used in countless ways by our bodies and are produced by genetic sequences (Biology Online, 2002). Animals within a given breed may vary in growth rate and body composition, but generally, there is a tendency for animals of a given breed to grow and develop in a characteristic manner that will eventually produce carcasses with distinctive characteristics that are peculiar to the breed (Forrest et al., 1975).

The estimate breeding values (EBVs) for important traits reflect the value of the animal's genes for that trait relative to the mean of the foundation animals. For example, a rabbit with a +2.5 EBV for growth rate

has genes estimated to exhibit an additional 2.5 grams per day of growth compared to the original animals of the flock. This equates to an extra 210 grams of saleable rabbit over a 12-week growth period. When this is multiplied over all animals in a rabbitry, the improvements in profitability will be self-evident (Brown, 2002).

2.2.5 Environment and management

Pond and Pond (2000) and Lawrie (1998) argue that the environmental conditions under which animals are reared can have a marked influence on their growth rate, and even on their body composition. The impact of temperature on rabbits has been studied by various researchers. According to Lawrie (1998), the development of many animals is prolonged by low temperatures, while high temperatures frequently retard the growth capacity of other livestock. High temperature also affects growing rabbits negatively reducing rates of live weight gain (Chericato, Botti, Canali & Rostellato, 1995). When rabbits are raised at 18-20°C they can reach a live weight of 3 kg by 112 days, whereas at 30-31°C they can only reach 2.5 kg. Lawrie (1998) comments that in general it is not the degree of heat alone which causes distress to animals in the tropics but its combination with humidity and the duration of these conditions.

Nguyen Quang Suc, Dinh Van Binh, Le Thi Thu Ha & Preston (1996) note that high temperature affects spermatogenesis, reducing the volume and concentration of ejaculates and also affects sperm motility after 8 hours at 36°C or 14 days at 30°C. Due to the reduction in feed intake

Studies on the effects of housing systems on performance of rabbits (Nguyen Quang Suc et al., 1996) reveal that the rabbits reared in underground shelters are heavier than the rabbits in cages. Most of the farmers observed that the rabbits in the underground shelters eat more than those in cages. The greatest disadvantage of the cage system is that the rabbits are exposed to high temperatures during the hot season. The suitable ambient environment for rabbit production is a temperature range of 18-28°C and humidity between 80 and 86%.

2.2.6 Sex

In most species of animals, the female matures earlier, but the male is larger and heavier than the female in adult life, and since the different parts of the tissues of the body grow at different rates, the difference in size between the sexes results in a difference in development of body proportions (Piles, 2000). According to Warriss (2000) male animals are leaner than females and produce the leanest carcasses, but they also grow to a larger mature size. Lawrie (1998) noted that in comparison with females, the muscles of the male neck and thorax grow relatively fast. Forrest et al. (1975) noted that the testes of males produce hormones that are associated with growth and development. Males produce carcasses with more muscle than do castrated males. Castration in either sex tends to reduce sex differences in growth rate and body conformation (Lawrie, 1998).

2.2.7 Age

As animals get older and heavier, the proportions of fat to muscle and to bone in their carcasses increase (Warriss, 2000, Parigi-Bini, Xiccato, Cietto & Dalle Zotte, 1992). It is generally observed (Lawrie, 1998) that the birth weights of the offspring from young mothers are lower than those from mature females.

2.3 Factors affecting rabbit carcass and meat quality

2.3.1 Environmental effects

Environmental effects refer to the temperature and season of the year at which the animal was slaughtered. In this case temperature is the most determining factor of the quality of meat. The rabbit's energy expenditure depends on the ambient temperature. Feed intake to cope with energy needs is therefore linked to temperature (The Rabbit Meat Quality, 2002). Dalle Zotte (2002) noted that as the temperature rises the water consumption increases, but at high temperatures, over the thermoneutrality value, feed and water consumption decline, affecting the performance of growing rabbits. This leads to a lower market weight at the slaughter age, which is economically a disadvantage for producers and processors, particularly if consumers prefer heavy carcasses. On the other hand, it may lead to a better slaughter yield because of the lower proportion of skin, empty gut and offal (Chericato, Rizzi & Rostellato, 1993).

According to Pla (2001) temperature has a clear effect on feed conversion ratio. It is around 21% higher at 30°C than at 18°C. In the study conducted by Pla (2001), it was revealed that the carcass weight of the animals reared at 30°C is greater than the weight of animals reared at 18°C. As a result the dressing percentage at 30°C is also higher. It was further noted that the rabbits reared at high temperatures demonstrated the strongest colour and this is attributed to the fact that they were also slaughtered at an older age.

Temperature seem to have an effect on the liver and kidney weight. The rabbits reared at 30°C had a lower kidney weight and a much lower liver weight than those from the 18°C group. Chericato et al. (1993) also found a lighter liver weight in rabbits reared in summer than in winter. This may be due to a lower metabolic activity and less glycogen.

According to Chericato, Bailoni and Rizzi (1992) rabbits reared at high temperatures are less fatty than those reared at low temperature. One reason for this may be due to the fact that at temperatures between 5°C and 30°C feed intake drops from 180 to 120 g a day respectively, and water intake rises from 330 to 390 g (The Rabbit Meat Quality, 2002). The meat subjected to higher temperatures is less acidic, paler with less fat, but no differences in water holding capacity, cooking losses or moisture and protein percentage between the animals reared at the two temperatures were noted (Chericato, Rizzi & Rostellato, 1996). According to Baldo (cited by Gittens, 2000) the climate in South Africa favours the

production of rabbits and this puts South African breeders on the positive side over other African countries.

2.3.2 Rearing techniques

Commercial rabbit producers house rabbits in caging systems with cage sizes adjusted for the breed of rabbit, management system, and intended purpose. Most large rabbitries have single deck cages, because of the ventilation problems inherent in multi-deck caging systems.

The high temperatures during the hot season in the cage system affect growing rabbits negatively by reducing the rates of live weight gain as a result of the reduction in feed intake (Lebas et al., 1986). The reduction of growth rate affects the slaughter weights and thus the carcass and meat traits as a result of reduced maturity. An opposite tendency was observed by Dal Bosco, Castellini & Mugnai (2001) that cage reared rabbits had the highest weight gains, lowest mortality rate and feed:gain ratio. According to Ouhayoun (1998) a decrease in growth rate enhances the relative growth of early maturing tissues (digestive tract, bone) at the expense of the late-maturing muscle and fat. Such a process reduces slaughter yield, meat:bone ratio and fatness. Dal Bosco et al. (2001) recorded the differences in colour parameters as the highest values of hue and the lowest of chroma in cage-reared animals. Selection for growth rate combined with confined rearing favour the anaerobic metabolism of rabbit muscle tissue. The cage-reared animals therefore have a higher proportion of white muscle fibre, which gives the meat a lighter colour. In addition, collective rearing improved animal transport stress resistance because of favourable environmental adaptation.

A few studies, which compared cage-reared to floor-reared meat rabbits, found that production performance of rabbits was similar between the two housing systems up to 70 days of age. After 70 days, stocking density became an important factor (Nguyen Quang Suc et al., 1996). A concern is the spread of coccidiosis in floor-reared rabbits. Future research that focuses on different production philosophies and their companion systems can help to elucidate the benefits of each system to both humans and animals (Harkness, 1988). Nguyen Quang Suc et al. (1996) noted that during the growing-fattening phase, the rabbits in underground shelters were 17% heavier after one month and 19% heavier after three months with the average growth rates being 20% higher. Maertens and Van Herck (2000) reported that animals raised in pens exhibits lower growth rate, poorer dressing percentage and lesser perirenal fat percentage and this may be attributed to the fact that they are more physically active.

2.3.3 Feeding effects/Diet

Feeding and nutrition are important aspects of any animal production enterprise. Quantifying feed and water intake is important in order to ascertain the economics of the rabbit enterprise (FAO, 1999, Sell & Aakre, 2002). It also helps in the early detection of health problems which first sign could be a lack of appetite or an excess of drinking. This implies that it is necessary to have a clear understanding of proper

nutrition and feeding for successful rabbit production. It is recognised that purchasing feed in bulk can result in considerable cost savings (McLeod, 2002).

According to Ouhayoun (1998) the diet has a marked effect on the relative development of organs and tissues and thus on anatomical carcass composition, as well as on the biochemical balance of the muscle. Dietary lipids also have an effect on the physical properties of fat as well as on the organoleptic properties of meat (Pla & Cervera 1997). Although the dietary fatty acid profile of the diet cannot modify the total lipid content in the muscle tissue it can alter its fatty acid composition considerably. Similarly, Dalle Zotte (1995) noted no significant effects on the chemical composition of meat, but he observed that the lipid content increased as a result of the addition of animal fats.

Schoenian (2002), Perrier and Ouhayoun (1996) made it clear that the rabbit's nutritional needs vary according to its age and physiological status. This means that in order to obtain a better carcass shape and intermuscular fat inclusion during fattening, the diet must be adjusted in such a way that it contains more concentrated energy than the one formulated for the post-weaning period (Dalle Zotte, 2002). Baldo (cited by Gittens, 2000) says the production of rabbits in Europe is more successful than in South Africa because farmers in Europe have a wider choice of feed. In South Africa there is only one pelleted feed available for rabbits with a protein content of 16, while in Europe there are three pelleted feed formulas with a protein content of 13, 16 and 18%. Each formula is specifically made for a certain stage of rabbit life (Baldo, cited by Gittens, 2000).

The change in the dietary energy content from the post-weaning period to the high energy content during fattening does not have any negative effect on the growth, the feed intake and the carcass yield (Lebas Coudert, Pouvier & Rochambeau, 1986, Xiccato, Parigi Bini, Dalle Zotte & Carazzolo, 1994). An increase in the level of energy supply during the finishing period generally has a positive effect on tenderness, juiciness and flavour, which is most likely due to an increase in intramuscular fat deposition and a decrease in the heat stability of the muscle connective tissue. However it is important to note that if a rabbit is used to a certain diet, the change must be made gradually to allow the rabbit's digestive system time to adjust (McCleod, 2002).

Dalle Zotte (2002) stresses the fact that a diet which perfectly fulfils the animal's requirements does not only help in the best growth potential, but it also significantly reduces both the feeding costs and the nitrogen and mineral excretion. According to the Pet Center at Southern States Cooperative, the quality of protein is related to the amino acid make-up and a well-balanced diet, in terms of amino acids, usually contains between 15 and 20% protein. Dalle Zotte (2002) argues that protein intake permits the maximum expression of muscular protein synthesis, promotes growth and maintains it. Feeding rabbits *ad libitum* obtains best performance in meat production (Lebas et al., 1986). According to Dalle Zotte (2002) and Gondret et al. (1998) growth, feed efficiency, slaughter yield, carcass adiposity and lipid content are seriously compromised when rabbits ingest less than 85% of the diet *ad libitum*, therefore, this level of intake does not lead to profitable meat production. The relative weight of the digestive tract is decreased

by the retention time of feed during *ad libitum* feeding. Thus the dressing proportion is increased (Ouhayoun, 1998). However, rabbits require a certain fibre quantity (130-140 g crude fibre/kg). Energy intake can be increased by adding fat to the fibrous rabbit diet (Dalle Zotte, 2002).

Dalle Zotte, Ouhayoun, Parigi Bini & Xiccato (1995) further noticed that dietary treatment may not affect the slaughter weight and correlationally, the growth rate of rabbits as well as metabolic and chemical traits of muscle and meat. In the same study the diet had an effect on the pH of the *longissimus lumborum* (LL) muscle, the lowest pH values were obtained from the animals fed a diet characterised by a low digestible energy (DE) and the highest digestible protein (DP). Melton (1990) noted that starchy foods and sugars fed before slaughter can help restore depleted muscle glycogen levels to allow development of a normal post-mortem pH. Provided there are no serious nutritional deficiencies, diet plays only a minor role in final meat quality.

The Pet Centre at Southern State Cooperative (2002) suggests three ways of feeding rabbits:

Self-feeding: In this case feed is placed in containers from which the rabbits may eat until they're full. This type of feeding is done once a day, usually in the evening, but it is important to feed at the same time each day.

Full-feeding: In this case the feeding is done by hand feeding once or twice daily, but increasing the feed allowance until the rabbit cleans up all the feed or just has a few pellets left at the next feeding. In this way the stock always has fresh feed.

Restricted feeding: this type of feeding is suitable for dry does and young breeding stock. It is a lower-than-normal feed allowance which is hand-fed once or twice daily; it helps in preventing the animals from becoming too fat as a fat rabbit has a lower reproduction rate.

2.3.4 Pre-slaughter conditions

The post-mortem changes that take place when muscle is converted into meat have a marked effect on the quality of the meat. The pre-slaughter handling of meat animals is one of the intrinsic factors influencing meat colour, appearance and quality (The Meat Tenderness Debate, 2001, Rabbit farming, 2002). After slaughter the glycogen in the muscle is converted into lactic acid causing a fall in pH from an initial value of pH 6.8-7.3 to about 5.4-5.8 at rigor mortis (Yong-Soo Kim, 1998). Forrest et al. (1975) outlined pH values that are possible in meat to be around 5.2-6.8 and the isoelectric point of the muscle 5.0-5.4.

A rapid decrease in pH may be the result of stress prior to slaughter. Some causes of this stress are due to fasting, rough handling of animals or fighting before slaughter (Masoero, Riccioni, Bergoglio & Napolitano, 1992). The muscle glycogen is released into the blood stream and, after slaughter, is rapidly broken down to lactic acid while the carcass is still warm (Lawrie, 1998). This high level of acidity causes a partial breakdown of muscle structure which results in pale, soft and exudative meat (termed PSE) - a

condition mostly occurring in pigs - dark, firm and dry (DFD) conditions, both of which have poor eating and keeping quality (Lawrie, 1998).

Dalle Zotte et al. (1995) confirmed that the meat from transported rabbits have higher pH and is less colourful. This is in agreement with Masoero et al. (1992) and Dal Bosco et al. (1997) that long-term stress before slaughter or starvation uses up the glycogen so that less lactic acid is formed after slaughter, resulting in an abnormal muscle condition which remains dark purplish-red on exposure to air (DFD) instead of a bright red colour.

Since pH is an important determinant of microbial growth, it will be obvious that the ultimate pH of meat is significant for its resistance to spoilage. However, PSE and DFD meat are perfectly safe to eat but limited in their processing capacity. PSE meat has higher drip and cooking losses due to the reduced water-binding capacity (WBC). Additionally to this pale colour, the meat has less flavour than usual (Lawrie, 1998). Rabbits should not be fed for twenty-four hours prior to killing (Sandford, 1986). This helps to empty the digestive system and to reduce the risk of the latter breaking during cleaning of the carcass. The underlying reason for keeping the digestive system intact is to avoid chances of contaminating the meat by its contents, which may lead to food poisoning of consumers (Fielding, 1991).

2.3.5 Transport

Transport has been shown to affect rabbit meat by increasing the rate of muscle glycogen depletion. This causes dark, firm, dry meat, increased plasma glucose, increased liver glycogen and decreased liver weights (Trocino, et al., 2002, McNitt, 1994). In the same study Trocino et al. (2002) found that transport duration had an impact on dressing percentage as it decreased from 59.5 to 58.9% ($p < 0.01$) when calculated on the live weight at breeding but it showed an increase when calculated on slaughter weight 61.0 to 61.7%; ($p = 0.07$). In addition Dal Bosco et al. (1997) recorded high pH values in the meat of rabbits that were transported for a longer distance. This higher pH led to increased water holding capacity, reduced cooking losses and an increase in shear force.

2.3.6 Slaughtering method

Under normal circumstances rabbits should be slaughtered when they are ready, which means at the correct stage of growth for slaughter. This is the time when their growth rate is at its optimum; in this case, their live weight gain per week does not increase anymore (Fielding, 1991). As a general rule, killing should be carried out as quickly and as effectively as possible with minimum of pain to the rabbit (Fielding, 1991). This can be achieved by quickly rendering it unconscious, followed by using one of the most commonly used methods for killing rabbits. They include stunning the animal or dislocating its neck and then removing the head to allow bleeding (Arrington et al., 1976, Sandford, 1986). For commercial purposes dislocation of the neck is recommended as it does not cause any damage and it allows processing large numbers of rabbits within a short period of time. However, this method requires a little

strength and practice and as a result it may not be successfully performed by young unskilled persons (Sandford, 1986).

People with less strength and experience usually opt for the stunning method. This method involves different techniques. One such technique uses electroshock with a V shaped metal electrode. It is the most usual and satisfactory method in rabbit processing and packaging stations, this method is followed by decapitation or by bleeding which both contribute to a whiter meat (Anil, Abm & McKinstry, 2000, Sandford, 1986). Another stunning technique is performed by hitting the rabbit sharply with either a stick, metal or with the side of the hand at the base of the skull between the ears (Sandford, 1986). With this method, special care should be taken to avoid hitting the rabbit on the shoulders, because this can result in a discoloured carcass (Sandford, 1986).

The forefeet, skin, intestinal tract and lungs are removed immediately after removing the head. The liver, kidneys and heart remain with the carcass. Once this is done the carcass is then washed with clean cold water to remove hair and any soil or debris. It should then be stored at a cold temperature. Dressed carcasses should not be held in water for a long time as this makes it absorb moisture, which in meat, is classified as a contaminant (Arrington et al., 1976).

2.3.7 Genetic effects/breed

In the rabbit the genetic variability between breeds and crosses plays a major role in determining the quality of meat. The most commonly used breed types for meat production have an adult mean weight of at least 3.5 kg and usually range between 3 and 4 kg (Ouhayoun, 1998). Meat rabbits may be of the same breed or crossbred. Crossbreeding (mating of individuals from different breeds) results in a phenomenon called hybrid vigour or heterosis in which the crossbred offspring are superior to the average of their purebred parents (Schoenian, 1998). Crossbreeding for meat purposes is very popular and often desirable, since crossbreeding improves the hybrid vigor in the fryers (Arrington et al., 1976). This, however, requires maintaining two purebred breeds and marketing the offspring. Replacement stock from the crossbreeding of two breeds should never be kept as each generation deteriorates in disease resistance, breeding consistency, litter sizes and hybrid vigour (Sandford, 1986).

The only exception would be in the case of developing a new breed or variety and this requires extensive knowledge. The most popular use of crossbreeding for meat purposes is in the use of a California buck on New Zealand White does. The resultant fryers are called "Smuts," and are often highly desired by processors (Lamar, 1998). California and New Zealand White rabbits are by far the most popular for a meat operation (Green, 1999, Rudolph's Rabbit Ranch, 2002, Schoenian, 1998). Lamar (1998) emphasised that the white-skin rabbits usually sell for about twice the price of the coloured and when the business is operated strictly on a meat-marketing basis there may be an advantage in using the rabbits with the white coats.

The California is a commercial meat rabbit and it is the second most important meat-producing rabbit, being second to the New Zealand White (Sandford, 1986, Green, 1999, Sell, 2002). New Zealand White rabbit is characterised by white skin with black hair on the nose, ears, feet and tail and albino eyes. The body is of medium length with well-developed shoulders and hindquarters (Arrington et al, 1976). These medium breeds are recommended for meat production because they are more economical than very large breeds, which eat a lot but cannot produce much more meat (Seymon, 1992). Hence a commercial producer should go for table rabbits that are likely to weigh 2 kg in nine to ten weeks, and will produce the greatest amount of profit.

However, producers aiming to produce whole carcasses for marketing in butcheries or in supermarkets should consider using breeds with short backs in order to improve the appearance of the carcass. These include New Zealand, California and German Tops. On the other hand, Raharjo et al. (1992) says those producing rabbit meat for pre-packed portions are advised to go for breeds with longer backs and a slender short front section as they produce a higher yield in valuable pieces. These include Giants and the Belgian hare. According to Green (1999) there is little difference between the two breeds so the choice depends entirely on personal preference.

2.3.8 Technological factors

The properties of meat that are of most interest to the consumer are strongly influenced by carcass treatments in the first few hours of post mortem. Both storage time and temperature have a great effect on colour stability, in the sense that colour acceptability decreases as storage time increases. However, the acceptability of colour on storage is significantly influenced by storage temperature (Lawrie, 1998). Therefore, fresh meat and meat products should be stored at temperatures of -1.5°C (29.3°F) to give maximum colour, shelf-life and safety of products (Warriss, 2001).

Under normal conditions, low pH values are not reached until the carcass has reached temperatures, which are low enough to prevent excessive protein denaturation. If lactic acid builds up too quickly resulting in a rapid pH decline, denaturation of the muscle protein can result in loss of tenderness of the meat, loss of juiciness, and less intense (or pale) muscle colouration. If cooling occurs at temperatures above zero the rabbit meat tenderness is not affected (Ito, Kamisoyama & Osada, 1986). The disadvantages of freezing are summarised by Kropf & Bowers (1992). They include freezer burn, product discolouration, unevenness of colour, product bleaching and loss of nutrients associated with drip loss. Moisture loss occurs from the exposed muscle surface of carcasses during storage. To minimise this loss, retail cuts are wrapped with material having a low water vapour transmission rate. Unfortunately, some of the moisture may still be lost even after packaging with this type of material. The free water may exude from the cut surfaces and accumulate around the meat causing a wet, unattractive retail package. This production of visible meat juice is known as weep and in its worst stage, the products lose weight and value to the wholesaler and retailer. These products also lose palatability as well as some of their soluble proteins, vitamins and minerals (Forrest et al., 1975).

However, chilling duration has to be taken into account because if rabbit carcasses are exposed to short chilling, muscular energy reserves are not completely affected. Instead the meat appears exudative and shows high pH values (Dalle Zotte, 2002). Other findings indicated that fast carcass chilling tends to lower the rate at which the ultimate pH is reached, consequently resulting in a higher WHC and yield of carcasses (Hulot & Ouhayoun, 1999). In addition, Arrington et al. (1976) noted that freezing has little effect on the quality of rabbit meat.

2.3.9 Biological factors: age and weight

In farm animals, it is widely believed that the effect of age on meat quality depends on factors such as species, muscles involved, and the changes in the muscle composition (Gondret et al., 1997, Lawrie, 1998). They further noted that with an increase in age of rabbits the meat becomes more tender. This is partly attributed to the fact that the muscle lipid content increases with age.

Other characteristics associated with age include darkening of meat due to increased levels of myoglobin (Lawrie, 1998). With advancing maturity the lean becomes progressively darker in colour and more coarsely textured (Burson, 1997). Moreover meat flavour also intensifies with age. For example, the flavour of meat of older animals, especially sheep, may be so intense that some find it to be objectionable.

According to Kohlen and Ducro (2002), increasing the adult body weight and reducing the rearing period have an effect in carcass composition and meat quality of meat rabbits. This means slaughtering at a fixed weight as defined by the market and consequently at a younger age. The body characteristics of rabbits slaughtered at a given weight depend on how quickly they have reached that weight. Rapid growth disadvantages early maturing tissues, conversely it enhances late maturing tissues of rabbits. Rapidly grown rabbits consequently have a higher slaughter yield, a higher muscle:bone ratio, total adiposity and muscle lipid content than those of slower growing rabbits (Ouhayoun, 1998). Dalle Zotte (2002) highlighted the fact that carcass quality and meat quality change markedly with the animal's age or weight at slaughter. This implies that the overall quality improves as growth increases.

The anatomical composition of the rabbit varies with age. The proportion of muscle mass to body weight remains constant over 2 kg live weight for a strain weighing 4 kg (adult animal). But the proportion of fatty tissue tends to increase. Indeed meat and carcass characteristics depend on the age of the animal and its weight at a given age (Ouhayoun, 1998). The body weight increases as a function of age, therefore it implies that age has an impact on a number of factors determining the quality of meat.

2.4 Factors that are influenced by age

2.4.1 Dressing percentage

Dressing percentage is the relationship of the weight of a dressed carcass to the weight of the live animal, expressed as a percentage (Blasco et al., 1992). The dressing percentage varies depending upon the

quality of the animal at slaughter, breed, age, amount of fat and the number of internal organs left with the carcass (Fielding, 1991). Animals with good meat characteristics have a higher dressing percentage than thin animals. Normally the liver, heart and kidneys remain with the carcass and are included in the carcass weight (Fielding, 1991, Ireland, 2001).

Past research has amply demonstrated that at a younger age and at a lower body weight there is a rapid increase in dressing percentage than in older or heavier rabbits (Szendro et al., 2002). It is widely held that the dressing percentage in rabbits of different body weight keeps increasing until the animals reach a body weight of 2.8 kg and remains constant thereafter (Sandford, 1986). Animals that are in average condition or slightly better than average have dressing percentages of about 55% while good quality animals' reach a dressing percentage of 60% or higher and younger animals dressing percentage is less than 50% (Arrington et al., 1976). Although selection for growth rate produces benefits (mainly due to an improvement of feed efficiency), some undesirable economic consequences for the producer are related to the use of less mature animals. This is attributed to the fact that when rabbits are sold as whole carcasses the payment is done on the basis of the dressing percentage, which is lower in less mature animals (Pla, Hernandez & Blasco, 1996).

Breed variations were found in the data obtained by Ireland (2001) from New Zealand White and Dutch rabbits of different ages that were fed a commercial rabbit feed showed that the dressing percentages of the Dutch were greater than those of the New Zealand. The dressing percentage also increased between 8 and 13 weeks of age, but declined slightly in the mature rabbits. Mature rabbits in this study were limited which may account in part for the lower dressing percentages. Normally, dressing percentage increases with age until rabbits approach maturity (Sandford, 1986).

2.4.2 Water-holding capacity

Water is quantitatively the most important component of meat comprising up to 75% of the total weight (Warriss, 2000). It is defined as the ability of meat to retain its tissue water present in its structure during application of external forces such as cutting, heating, grinding or pressing (Forrest et al., 1975). Hence water-holding capacity (WHC) is regarded as an important quality parameter of meat (Varnam et al., 1995) mainly for the following reasons:

- The drip or exudate that results from poor WHC detracts from the appearance of the meat
- Loss of drip leads to weight loss in fresh meat, and in processed meats poor WHC may reduce water retention and therefore yield of product.
- WHC is thought to influence the perceived juiciness of fresh meat after cooking.
- Meat with low WHC loses a lot of fluid in cooking and may taste dry and lack succulence.
- The chemical composition of the lean, in particular its protein content may be important in determining the yield and quality of processed products.

The extent of drip loss from meat is largely a function of post-mortem changes, predominantly those affecting the ultimate pH value of the meat and the extent of changes in myofibrillar volume (Varnam et al., 1995). The water-holding capacity of muscle tissue has a direct effect on the shrinkage of meat during storage. When the tissues have poor water-holding properties, the loss of moisture and the loss of weight during storage (shrink) are great (Forrest et al., 1975). Meat is sold by weight, thus drip loss must be minimised for economic reasons. It is unsightly to the consumer and excessive drip is a negative determinant of meat quality (Varnam et al., 1995).

2.4.3 Meat yield

The yield of product is important because it determines how much you have to sell. Higher yields mean more product and potentially greater profit. In meat, this could mean a higher proportion of carcass relative to the weight of the live animal or a higher yield of saleable lean and fat to non-saleable waste bone (Warriss, 2000). According to Hernandez, Pla and Blasco, (1996) the meat:bone ratio of the hind leg gives a fairly good prediction of the meat:bone ratio of the carcass. On the other hand, Blasco et al. (1992) noted that the carcass weight, length measurements, length ratios, retail cut weight or hind leg meat are bad predictors of the percentage of meat of the carcass. Some combinations of these measurements in a regression equation are nevertheless, fairly good predictors. However rabbits produce low-fat meat and have the best meat:bone ratio of any meat-producing animals, except turkeys (FAO, 1999).

The shape of muscles is important, as well as the overall yield of lean, because this affects their attractiveness. Plump, rounded muscles are more attractive than thinner; flatter ones (Warriss, 2000). The future for rabbit meat production looks promising because rabbits consume a high forage diet, and do not compete with humans for food. A rabbit can produce approximately five times more meat per body weight than a beef cow (FAO, 1999). Gittens (2000) asserts that a rabbit is one of the most productive livestock. It is estimated that a 5 kg doe can produce up to 200 kg of meat in a year, which is a far better rate of productivity when compared to that of a cow. On the other hand Baldo as cited by Gittens (2000) states that a 5 kg animal will produce 80–100 kg of meat per year on 0.5 m². Additionally they also ensure food security as they convert low quality feed into meat (Gittens, 2000).

2.4.4 Carcass yield

Rabbits of the same age, regardless of their weight, exhibit approximately the same slaughter yield. They also have similar muscle:bone ratios. Body weight at slaughter has no significant effect on these characteristics, probably as a result of both the variability in adult body weight and in early growth rate of rabbits (Ouhayoun, 1998). Slaughter yield improves with age. For a given carcass weight, animals with a high growth rate, receiving more balanced feed, generally have a better carcass yield (Szendro et al., 2002). However, slaughter yields can vary greatly from one country to another because some carcasses have no head, no viscera, and of course no paws, depending on how each country define the yield (Sandford, 1986). Yields also vary among breeds and according to age and diet. Too much roughage in

the diet tends to overdevelop the digestive tract and thereby lowers the yield. Animals characterised by small bones and thin skins are of good quality, and they yield a higher dressing percentage than those with large bones and thick skin.

Fryer yield of carcass varies from 50-59% of its live weight, 78-80% of which is edible. Factors that affect the dressing percent include age of rabbits, in that mature rabbits ready for the market, yield a higher dressing percentage than the younger ones (Arrington et al., 1976). The recommended weight for slaughtering the animals is between 2 and 2.8 kg which are normally after a period of 8-10 weeks. The yield of the carcass for the animals at this stage is 54-61% and the additional advantage is that at this point in time the meat will satisfy consumers due to its tenderness (Gomez et al., 1997).

2.4.5 Fat content

Meat fat content is highly related to quality as fat content has been shown to affect flavour, juiciness and tenderness of meat (Miller, 1994). All fats and oils from animals contain mixtures of both saturated fatty acid (SFA) and unsaturated fatty acids (UFA). Despite the common reference to animal fats as saturated, less than half of all fatty acids of meats are saturated. Major fatty acids that are found in meat include the saturated fatty acids (SFA) namely myristic acid (C14:0), palmitic acid (C16:0), and stearic acid (C18:0), the monounsaturated fatty acids (MUFA) palmitoleic acid (C16:1) and oleic acid (18:1) and polyunsaturated fatty acids (PUFA) namely linoleic acid (C18:2), linolenic acid (C18.3) and arachidonic acid (C20:4). SFA and MUFA constitute the major fatty acids in meat fat (Lawrie, 1998).

Genetic factors and feeding practices can affect total fat deposition in animals. However, within species, genetics have little or no effect on cholesterol concentration or fatty acid profile. Feeding can affect the fatty acid profile of monogastric animals (such as pigs) to a much greater extent than ruminants. Dalle Zotte (1995) argues that apart from all other changes the fat content of the total hind leg (HL) muscles seemed to differ significantly during growth, One reason for this may be substantial intra-muscular and intermuscular lipogenesis. Despite the effect of age on the fat content, slaughter weight also influences dissectible fat content and muscle lipid content which both show higher values in the heaviest rabbits (Ouhayoun, 1998).

Studies by Ouhayoun (1989) and Pla et al. (1996) proved that large-sized rabbit breeds have lower fat contents than small ones. The absolute value of these differences is small, although the amount of dissectable fat in rabbit carcasses is generally very small - about 3% of the chilled carcass weight. In the case of weight the heaviest rabbits are characterised by perirenal adiposity and a muscle lipid content which is higher than those of lighter rabbits. Fat is also associated with flavour development and so at least a minimal level is desirable. Above this level, fat will need to be trimmed leading to waste and reduced overall value (FAO, 1999).

Piles, Blasco and Pla (1999) discovered that carcasses from females had more dissectable fat at slaughter weight than male carcasses. However, Pla (2001) observed that male carcasses had a higher

quantity of total fat percentage than females using Gigante de Espana rabbits. This could be attributed to the fact that the females were much less mature at slaughter weight than the males in this breed and thus the known effect of sex tissue composition which favours the development of adipose tissue in females was not yet developed.

2.4.6 Juiciness

Juiciness is an important component of meat and palatability and it has two major components. The first is the impression of wetness produced by the release of fluids from the meat during the first few chews. The second is the more sustained juiciness that apparently results from the stimulating effect of fat on the production of saliva and the coating of fat that builds up on the tongue, teeth and other parts of the mouth. Juiciness is closely associated with marbling. Hence heavier, fatter animals produce meat that seems juicier. This is attributed to the fact that fat is softer than muscles. The extremes of juiciness are dryness and lack of succulence. Meat, which is criticised for lack of succulence, is attributed to either poor WHC or low levels of intramuscular or marbling fat. The human perceptions of tenderness and juiciness appear to be interrelated. Juicy meat may be perceived as more tender than a similar sample, which has inherently the same texture yet is less juicy (Warriss, 2000). The meat of young animals gives an initial impression of juiciness, but due to the absence of fat, there is ultimately a dry sensation in the mouth.

2.4.7 Texture/Tenderness

When an animal dies, blood stops circulating, and there is no new supply of oxygen or nutrients to the muscles. Without oxygen and nutrients, muscles run out of energy, they contract and become stiff (Kropf, et al., 1992, Warriss, 2000). This stiffening is called rigor mortis. Eventually, muscles become soft again after rigor mortis, which means that they are tender when cooked after this period (Northcutt, 1997). Tenderness is the result of inherent factors, such as the type of muscle and post-mortem events involving onset and resolution of rigor tenderisation (Varnam et al., 1995). On the other hand, Thompson (2002) and Allen (2002) widened and redefined meat tenderness as a function of production, processing, value adding and cooking method used to prepare the meat for consumption. In the same explanation Thompson (2002) further said failure of one or more links in the meat supply chain increases the risk of a poor eating experience for the consumer.

There are two main components of meat tenderness - a myofibrillar (muscle) component and a connective tissue (collagen) component. The size of muscle fibres increase with increasing age and may be tougher. Muscle fibre toughness can be minimised by good animal handling prior to slaughter, the use of electrical stimulation, correct handling procedures in the factory, appropriate carcass chilling practices, and by ageing post slaughter (Varnam et al., 1995). According to Northcutt (1997), anything that interferes with the formation of rigor mortis, or the softening process that follows it, will affect meat tenderness. Animals that struggle before or during slaughter cause their muscles to run out of energy and rigor mortis forms much faster than normal (McCormick, 1992).

It is documented that tenderness decreases with age, and this decline is associated with the fact that collagen (connective tissue) becomes less soluble and less digestible. In actual fact fibres of collagen are the major elements of connective tissue. As an animal ages, there is an increase in heat-stable collagen cross-links which result in decrease in the amount of soluble collagen, rather than an increase in the amount of connective tissue present (Petracci et al., 1999, Way, 2002).

Animals that are poorly fed will take a longer time to reach a useful size (slaughter age) meaning that they are therefore relatively old by the time they reach a size suitable for slaughter (McCormick, 1992, Way, 2002). This eventually provides meat of lower eating quality (Burson, 1997). Although meat generally becomes less tender as the animal ages, Arrington et al. (1976) argue that this is not the case during periods of rapid growth when meat actually becomes even more tender. Rapid growth rate is associated with chemical and structural changes in muscle tissue and these effects are attributed to differences in the rate of post-mortem ageing of the meat as rapidly growing animals have reduced activities of calpastatin - a substance that blocks the tenderising effects of the calpain enzyme. The connective tissue, which causes toughness, is diluted during periods of rapid growth (Lawrie, 1998).

Lamer (1998) points out that the greatest demand is for a rabbit that is not over 12 weeks of age and with some processors preferring fryers not over 10 or 11 weeks of age. There are very good reasons for this stipulation. At 12 weeks of age, the sex hormones in rabbits start activating. Testicles appear on the bucks, while the doe's reproductive system begins to blossom. The hormones involved in this process have a direct bearing on the tenderness of the meat. The meat becomes tough. An opposite tendency was found in the study conducted by Gondret et al. (1997) which compared the meat quality of 18-week-old rabbits and 11-week-old rabbits. They discovered that older rabbits tend to be more tender, less fibrous with more mouth coating than the younger rabbits. Indeed the increase in tenderness with age is attributed to the fact that with ageing there is a marked accumulation of fat in the *longissimus lumborum* (LL) muscle.

Tenderness varies with muscle age, and depends on changes in the proportion and type of connective tissue supporting the muscle fibres. The younger the rabbits are slaughtered, the more tender the meat will be. On the other hand, flavour tends to develop with age. Likewise juiciness depends largely on the fat content of the carcass. The fatter the carcass the lower its water content, but the better it retains the little juice it has.

Although age is a factor in meat tenderness, it plays a less important role than factors such as muscle location and animal condition (Burson, 1997). This is because connective tissue content varies from muscle to muscle depending upon its position and role in the body. The *longissimus dorsi* muscle has relatively low connective tissue content and animal age will have relatively little effect on its tenderness. Glycolytic metabolism develops during growth to the detriment of oxidative metabolism and the rate of this differentiation is not the same between muscles, according to the metabolic and contractile properties in the adult (Hulot et al., 1999). This is confirmed by the results of Dalle Zotte (1995) who indicated that the

glycolytic activity of the *longissimus lumborum* (LL) muscle increased during fattening while the *biceps femoris* (BF) remained constant. The energy metabolism is quite different in mature LL and BF muscle - the former being more glycolytic (Ouhayoun, 1998).

The increase in age is also associated with a decrease in pH (Dalle Zotte et al., 1995), thus WHC is lowered in the raw rabbit meat (Ristic & Zimmermann, 1992). On the other hand, Bernadini, Castellini, and Lattaioli (1994) never noticed any change in pH during growth when rabbits of ages 11 to 13 weeks were used. There are many contributing factors, which could explain the differences in these results. They included the variables like breeds, slaughtering techniques and/or differences in rearing conditions. Studies of pH (The Meat Tenderness Debate, 2001) have shown that although high pH meat are said to be consistently more tender than normal pH meat, such meats are darker in colour and will have poorer keeping qualities.

Xiccato et al. (1994) noted that the sensory properties of rabbit meat are not affected by age. However, this study may not give a very true picture, as animals were slaughtered with a two-week-age difference, which implies a very short period to provide important changes in muscle composition. Besides all factors affecting tenderness, it is wise to remember that in many countries, people prefer their meat to be tender and the value of different cuts or joints reflects this. For instance, fillet steak is both the most tender and most expensive cut of beef. However, many Africans prefer their meat chewy (Warriss, 2000).

2.4.8 Flavour

Flavour is another quality attribute that consumers use to determine the acceptability of meat. Both taste and odour contribute to the flavour of meat and it is generally difficult to distinguish between the two during consumption (Northcutt, 1997). With regard to these attributes Varnam et al. (1995) asserts that flavour and odour are closely associated, even though flavour is mainly determined by water-soluble constituents, while odour is determined by fat-soluble and volatile elements. The chemical components responsible for meat flavour are found in the water-soluble fraction. Odour becomes very important if abnormal odours or taints are present. Flavour is influenced by the deposition of compounds from the feed in the fat of the animal. This is very true in rabbit meat whereby flavours may be added to feeds in order to stimulate and regulate the feed consumption of fattening young rabbits. These flavours can dissolve in adipose tissue and theoretically influence the organoleptic quality of the meat (Ouhayoun, 1998). As the fat content of meat increases, so does flavour. Commercial rabbit meat has a distinctive but mild flavour, quite unlike the taste of wild rabbit which many people find too strong (McCormick, 1992).

2.4.9 Colour/Appearance

Colour of cooked or raw meat is an important characteristic in the choice of meat, because consumers associate it with the product's freshness, and they decide whether or not to buy the product based on their opinion of its attractiveness (Northcutt, 1997). According to Warriss (2000) colour is a major determinant

of appearance. Appearance is important because it is practically the only criterion the consumer can use to judge the acceptability of most meat at purchase. Forrest et al. (1975) asserts that the colour of meat is the overall first impression seen by the eye. It is directly influenced by the structure of the muscles involved, principles of reflection and absorption of light.

Colour of meat depends upon the presence of the muscle pigments myoglobin and haemoglobin (Varnam et al., 1995, Northcutt 1997). Haemoglobin is the pigment present in blood while myoglobin is found in muscles. Forrest et al. (1975) and Varnam et al. (1995) state that haemoglobin is also present in small quantities, particularly if bleeding has been inefficient. Forrest et al. (1975) add that myoglobin constitute 80-90% of the total pigment and is much more abundant than haemoglobin. The two major pigments are similar in structure, except that the myoglobin molecule is one-fourth as large as the haemoglobin molecule. Myoglobin is a watersoluble protein that stores oxygen for aerobic metabolism in the muscle. It consists of a protein portion called a globin (since it is a globular protein), and a nonprotein portion called a haem ring with a central iron atom. The haem portion of the pigment is of special interest because the colour of meat is partially dependent on the chemical state of the iron within the haem ring (Lawrie, 1998, Kropf et al., 1992). The appearance of the meat surface to the consumer depends, however, not only on the quantity of myoglobin present, but also on the type of myoglobin molecule, on the chemical state of the iron and on the chemical and physical condition of other components such as oxygen, water or nitric oxide attached to the iron portion of the molecule in the meat (Lawrie, 1998). Myoglobin concentration increases as an animal matures and with exercise.

The rate and extent that muscle pH declines during post-mortem are both very important because they have a great impact on the colour of meat and meat products. As mentioned earlier the normal pH decline in muscles is from approximately 7.0-7.2 down to near pH 5.5-5.7 over about 24 h (Lawrie, 1998). A very low pH of less than 5.4 leads to a paler colour, while a higher final pH results in darker meat. This rise in pH may also be due to a high level of pre-slaughter stress. This darkening of colour becomes noticeable when the muscle pH is above 5.7. Ultimately, a high pH can affect the colourstability of fresh meat because it affects enzyme activity and the rate of oxygenation. Muscle with a high pH has a dry surface and this inhibits the penetration of oxygen into the meat and thus slows down the oxygenation process.

Myoglobin levels vary according to breed and age, the concentration increasing with age. Forrest et al. (1975) noted that the muscles of immature animals have lower myoglobin content than those of more mature animals. Ultimately a greater myoglobin concentration yields a more intense colour. Moreover, meat colour can also be affected by sex. In this regard Trocino et al. (2002) found that *Biceps femoris* (BF) muscle was darker and less coloured in females than in males. Lawrie (1991) asserts that meat from male animals usually contains more myoglobin than that from females or the castrate at comparable ages. A high level of muscular activity also results in the production of more myoglobin. For example, myoglobin levels in muscles of animals reared under free-range conditions are likely to be higher than those reared intensively (Varnam et al., 1995). In this respect game animals have muscles that are darker than those of

domestic animals partially because of the effect of a higher level of physical activity on their myoglobin content (Warriss, 2000).

Rabbits produce white meat that is fine-grained and the rabbit carcass fat should also be white (Arrington et al., 1976). The major cause of yellow fat is the intake of the yellow carotenoid pigments, especially β - carotene, which can be metabolised to Vitamin A (a vitamin essential to many body processes). Excess β -carotene is stored in fat, giving rise to a yellow-coloured fat. Yellowish fat is increased by feeding green fodder, which can be offset by drying the fodder first. The tendency to form yellow fat, increases when one of the xanthophyll-reducing enzymes is missing. This characteristic is inherited recessively (Corino et al., 1998, Forrest et al., 1975).

Although rabbit meat is an "all-white" meat, the carcasses from coloured rabbits will have a slightly darker hue. This darker hue is most obvious when placed side-by-side with the carcass from an albino rabbit (Lamar, 1998). The coloured rabbits have more pigmentation. However, it cannot be said that all "white" rabbits do not have pigmentation, as some, like the Hotot, are pigmented. Thus, when a processor calls for "white fryers," it is generally understood to mean "white albino fryers." The albino whites will always have pink eyes, whereas the pigmented whites will have dark coloured eyes. This explains the additional popularity of the New Zealand White and California breeds in the rabbit meat industry, both of which are albino whites with pink eyes. In some cases, a processor may simply prefer the cleaner white meat from the albino breeds (Gittens, 2000, Lukefahr & Cheeke, 1990, Sonandi, Masika & Van Averbek, 1996).

Discolouration of meat can be related to the amount of these pigments (haemoglobin and myoglobin) that are present in the meat, the chemical state of the pigments or the way in which light is reflected off the meat. Discolouration can occur in an entire muscle, or it can be limited to a specific area, such as a bruise or a broken blood vessel (Northcutt, 1997).

Meat quality measurements are usually taken on meat cuts in beef, lambs or pigs, but rabbit carcasses are commercialised as a whole, thus colour measurements taken on the carcass surface seemed to be a sensible quality criterion (Pla, Hernandez & Blasco, 1996). However these authors indicated that recently a market for retail cuts has been developed and therefore this calls for taking measurements on the cut surfaces.

2.5 Conclusion

In the present review, numerous factors have been identified that affect the growth performance and subsequently meat quality in the rabbit. These factors include nutrition, water, hormones, breed, environment, management, sex, age, slaughtering methods and transport. For the purpose of this study conclusions regarding influence of age and breed were highlighted.

- Older rabbits have a higher dressing percentage than young rabbits.

- The younger the rabbits are slaughtered the more tender the meat will be. On the other hand, flavour tends to develop with age due to accumulation of fat.
- The meat of young animals gives an initial impression of juiciness, but due to the absence of fat, ultimately a dry sensation in the mouth follows.
- Yields also vary greatly according to age. In this regard slaughter yield improves with age.

To select breeding stock for a commercial meat-producing rabbitry that will be financially viable, essential factors to consider should include health and vigor of animals, brightness of eyes, and a smooth and glossy coat. In addition other factors that must be looked at are feed conversion, mothering ability, number of kits weaned, average weight at weaning and conception rates. The most important breeds for meat production in South Africa are the California, Cinnamon, New Zealand Reds, New Zealand Whites and hybrids which is a cross between Dutch red and California. This determination is based on size, fast growth rates, good feed conversion ratios, high dress-out weights and meat:bone ratios (Lamar, 1998).

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CHAPTER 3

Factors driving the food choice of rabbit meat

3.1 Introduction

Information about consumer needs is very important as consumers are increasingly demanding high quality products to maintain their health. They demand more and more lean carcasses, attractiveness and implicitly wholesome food stuffs (Mermelstein, 2002).

To meet consumer requirements, meat should contain the essential nutrients which include proteins, lipids and other components necessary for the growth of children and well-being of adults (Ouhayoun, 1998). According to Warriss (2000) meat should be free from parasites, microbiological pathogens and hazardous chemicals, which may be harmful to the human body. It should be free from residues of previous veterinary medication of the animal or from growth-promoting agents or from adventitious contaminants such as pesticides. Moreover, the storage ability of the meat is essential, it should contain as few bacteria as possible and have an acid pH that is not favourable to the development of micro-organisms (Ouhayoun, 1998).

The other important factors are the organoleptic properties which include presentation and conditioning of the carcass or the cuts, colour, consistency of raw meat, easy separation of cooked meat from the bone, texture, tenderness, juiciness and flavour (taste, smell and aroma) (Biology on line 2002, Ouhayoun, 1998).

Attractiveness of rabbit meat to consumers depends on the shape of the carcasses or the cuts, the level of fat, the colour and the absence of exudates in the packages, carcass weight and quality to price ratio (Dalle Zotte, 2002). The fact that rabbit meat contains little fat and a high proportion of polyunsaturated fatty acids, indicates that rabbit has a lot to offer consumers trying to cut back on their intake of saturated fats in meats. One other advantage of rabbit meat is that it does not present serious qualitative problems associated with the muscle biology during the pre-slaughter and post-slaughter handling period, when compared to other species (Sell & Aakre, 2002).

Consumers are also concerned about the time available for cooking which includes cutting and cooking the meat (Burson, 1997). In this regard producers are faced with the challenge to balance purchases of different cuts among multiple buyers.

3.2 Factors driving the food choice of rabbit meat

3.2.1 Sensory food acceptance

Apart from convenience, food acceptance can also be influenced by consumer reactions in which the human senses give a total impression of the sensory quality attributes of the food, although the sensory attributes of food are perceived individually, the human brain is able to integrate the perceived responses and form an overall impression of the quality of the product (Penfield & Campbell, 1990). Figure 1 is a model of the sensory basis of food acceptance, which was developed by Armand and Cardello (in Meiselman & Macfie, 1996). It illustrates the stages, interactions and measurement levels involved in the processing of sensory and perceptual information about food.

Food acceptance is an interplay of physical, sensory, perceptual and hedonic aspects pertaining to food. Sensory facilities that contribute to the acceptance of rabbit meat include vision that enables the consumer to judge the appearance of the meat regarding presentation in terms of size of cuts, handling practices, storage potential and final use. Basically consumers discriminate against size in that exceedingly small and/or large individual units are considered undesirable. Size, shape and form can also alter acceptability, potential market and final use. Above all, colour contributes even more to the assessment of rabbit meat quality than any other single factor (Cardello, 1996).

Audition, kinesthesia and somesthesia enables the consumer to judge the texture. The internal structural properties of rabbit meat are due to the composition of the cells, the structure of these cells and their supporting tissues. In this regard rabbit maturity has a significant bearing to the textural properties of a product. This judgement is mainly performed after purchase and consumption and plays an important role in learning to eat or to avoid rabbit meat. It empowers the consumer with memory schemata providing content that determines the expectation to further eating experience.

Gustation and olfaction determines flavour experiences before and during the eating experience and enables the consumer to decide whether to eat or not to eat rabbit meat. Additionally, physiological status (hunger and thirst) also determines whether the food is perceived as pleasant or unpleasant in terms of appearance, flavour and texture.

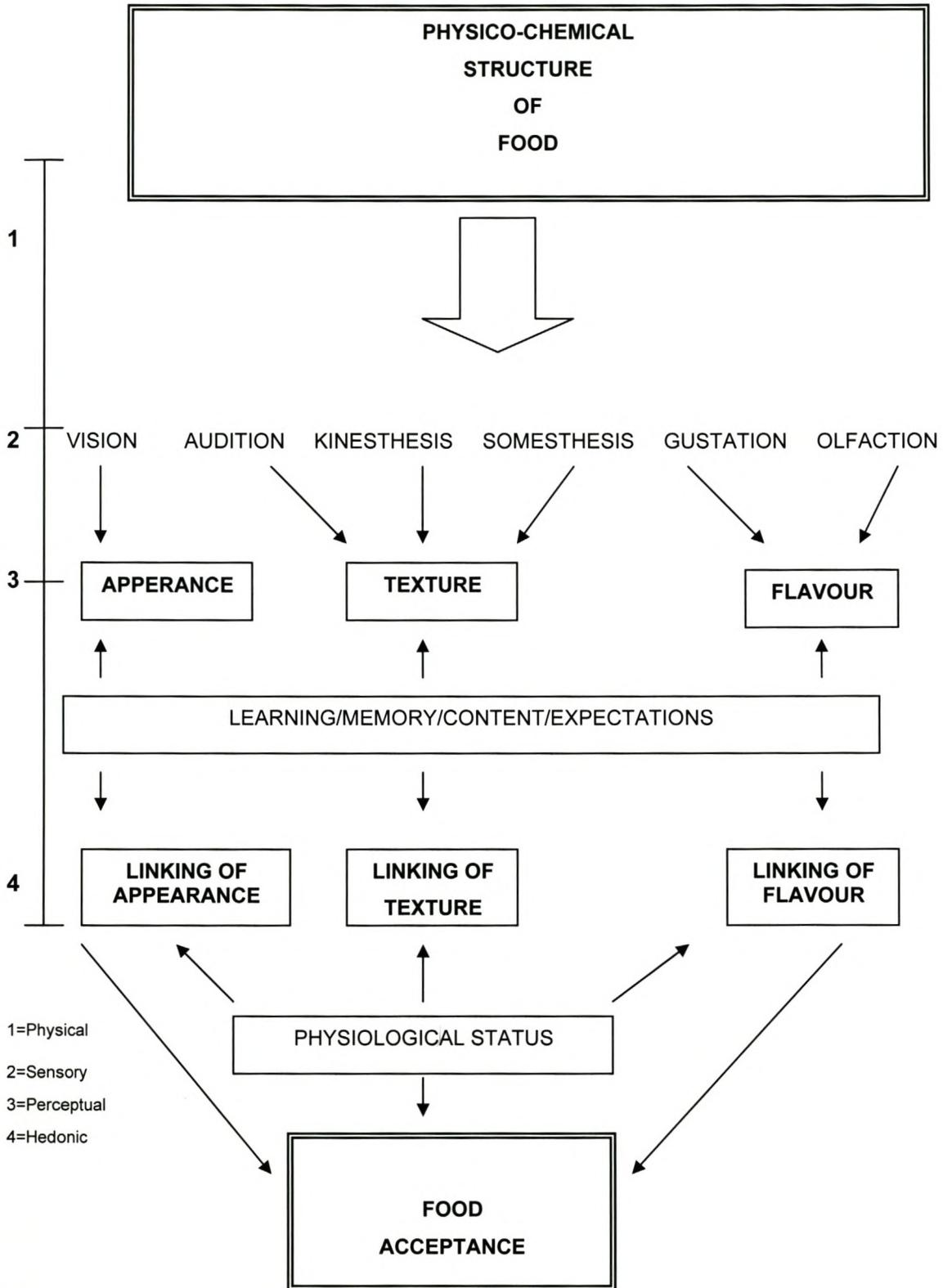


Figure 1

Food acceptance model of Armand and Cardello in Meiselman and Macfie, 1996: 554

3.2.2 Experience

Rabbit meat consumption is much easier to develop where people are already used to eating widely different kinds of meat, as from hunting. This would be generally true of black Africa. People with monotonous diets will find it harder to accept this new product (Lamar, 1998). However, a well-planned development campaign can do much to promote necessary changes in eating habits (FAO, 1999). In support of this statement, the results of the research conducted by Hoffmann, Kobling, Stier and Gall (1992) in Bobo-Dioulasso and Burkina Faso revealed that consumers who have eaten rabbit meat before were ready to spend more money on the rabbit carcass than those who had never tried it. When rating different animal meats in the order of preference, rabbit meat was rated fifth, the highest preference was for poultry, followed by mutton, beef and fresh fish.

Apart from the fact that a large number of the South African population, in particular the African population, grew up eating rabbit meat from hunting in the veld, there has been no formal market for rabbit products in the country (FAO, 1999). Gittens (2000) reported that there is a potential for rabbit meat marketing in South Africa, especially in the rural areas as they already discovered that the demand is greater than supply. This is confirmed by Billet (1999) that the rabbit meat industry is promising in Gauteng. Billy David and Mary Carr as cited by Billet (1999) have a strong feeling that the meat market in Johannesburg is undersupplied. They predict that the demand is likely to grow as the country becomes more cosmopolitan, because there is a niche market for rabbit meat in South Africa among the French, Portuguese, Italians and other continentals. Apart from the 15 000 Portuguese families in the PWV area there is a large number of South Africans who eat rabbit meat on regular basis (Baldo as quoted by Gittens, 2000).

3.2.3 Sociological profile

Merdji (1999) conducted a survey in France whereby it was concluded that the sociological profile of the rabbit meat consumer has not changed, in the sense that rabbit meat consumption is still limited to the rural and the elderly urban population. Young people are showing less interest in rabbit meat because rabbits are traditionally seen as pets. Jacobs (2000) noted that consumers would shy away from rabbit, because it is simply not a regular part of the consumer's diet, or perhaps because of sentimental associations with cute bunnies. Generally social-cultural inputs have a negative influence on consumers' decisions about a product for the simple reason that they emphasise the negative features of a particular product. The existing code of behaviour of family, friends, neighbours and society as well as marketing efforts affect consumers purchasing behaviour and product use (Schiffman & Kanuk, 2003)

3.2.4 Perception

Jacobs (2000) found that people are willing to eat rabbit but nevertheless shy away from this because it is simply not a regular part of the American consumer's diet. In addition, associating rabbits with pets and

not as a food-producing animal was also identified as one of the major constraints in rabbit meat farming (Lukefahr & Cheeke, 1990). This factor becomes obvious when producers are not able to supply enough stock due to the fact that they sell their fryers to temporary markets such as the Easter bunny trade. The fact that it resembles the hare, gives it a natural meat product characteristic and thus a "luxury product" by the urban population who generally come from high-income or middle-income socio-professional categories that love good healthy food. Its association with festivities and celebration means that its preparation is time-consuming, which explains its occasional consumption. This image is therefore in itself a mark of quality (Merджи, 1999).

3.2.5 Superstitions

Gittens (2000) stated that traditional beliefs are a limiting factor in marketing rabbit meat. Some African black cultures forbid the consumption of the New Zealand White due to the albino appearance because they strongly believe the pink-eyed rabbits will bring them bad luck (Green, 1999, Gittens, 2000). They do not have any problem with white rabbits. Their main problem is with the colour of eyes. With this in mind, Nyete, the manager of the Ciskei Rabbit Production Corporation (Gittens, 2000) stated that they cross-breed in order to come up with brown-eyed rabbits which are accepted by local people.

In a study conducted in South Africa, Sonandi, Masika and Van Averbek (1996) found that 79% of Xhosa people eat rabbit meat, but they culturally consider it to be suitable for boys only and not suitable for women and girls as it is believed to cause sterility and abortion. Some families do not allow their children to eat rabbit meat. They have the superstitious concept that if a child eats rabbit meat, his or her mouth and lips might grow to be like those of the rabbit.

3.2.6 Psychological factors

Food preferences are determined by physiological and psychological development and social experiences (Asp, 1999). In this regard, the foods most liked by consumers are those that the consumer is familiar with and which are considered to be pleasant. This food will then be eaten on regular basis. On the other hand the foods that have never been tasted or are unfamiliar, will likely be rejected for the fact that they are generally considered unpleasant. It is therefore obvious, that former exposure which determines the nature of the memory schemata of an individuals food landscape (foods viewed as per habitual food choice) is the most important determinant of food acceptability. In the model produced by Schiffman and Kanuk (2003), they present consumer-decision making in a broad framework of inputs, processes (throughputs) and outputs. The psychological field that consists of motivation, perception, learning, personality and attitudes normally determine the drive during the decision-making process, but is also adapted in the memory schemata after the post-purchase evaluation (eating experience) output and will in turn impact on the same aspects of the psychological field. Psychological factors represent the internal factors that have an impact on consumers' decision making process as: need recognition, pre-purchase search and evaluation of alternatives (Fig 3.2).

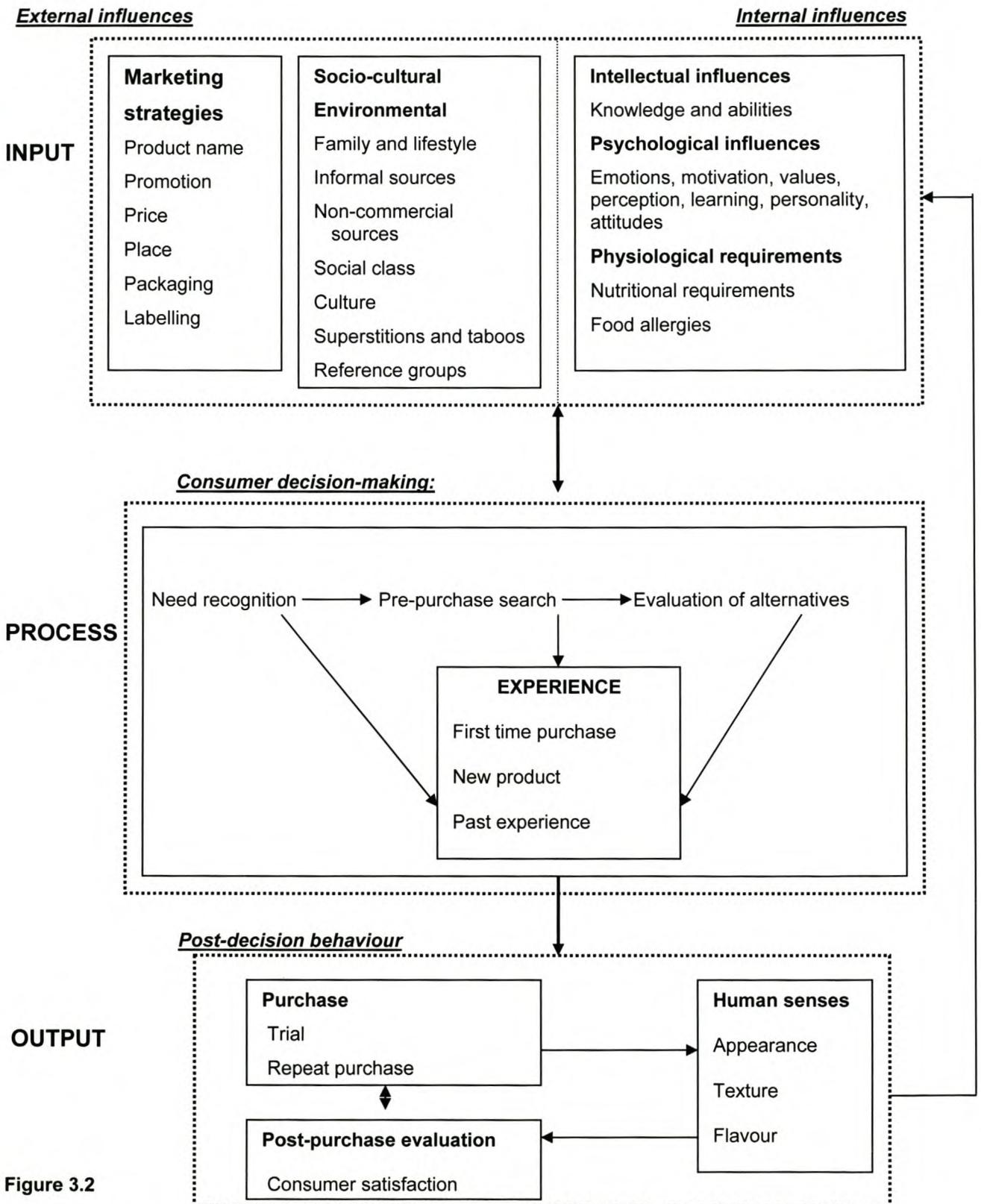


Figure 3.2

A simple model of consumer decision-making adapted from Schiffman and Kanuk, 2003

3.2.7 Religious beliefs

The religious beliefs also have a great influence on the consumption of rabbit meat because some religious denominations associate it with the meat of an unclean animal such as pork. Religion plays an important part in the lives of most people in Africa. A large proportion of Africans are mainstream Christians of whom most are Protestants. Some are Catholics and there is a growing number of Muslims. The diet varies considerably depending upon the person's religion (Sonandi, Masika & Van Averbek, 1996). According to Bennion (2000) a summary of the religious influences is as follows:

Christianity – There are no general dietary requirements. Some Christians observe Friday as a day when they do not eat meat. Some Christians may wish to abstain from food (fast) before receiving Holy Communion.

Hinduism – Most Hindus do not eat beef. Some will not eat eggs/chicken. Dairy produce is acceptable, so long as it is free of animal fat. Some Hindus are very strict vegetarians they will not eat food which has come into contact with prohibited food/utensils.

Islam – Muslims are forbidden to eat any products from pigs. Other meat can be eaten but it has to be Halaal meat, i.e. killed in a special manner stated in Islamic law. Fish and eggs are allowed but not if they are cooked near pork or non-halaal food.

Jehovah's Witnesses – Food containing blood or blood products is not acceptable.

Rastafarianism – All forms of pork and shellfish are forbidden. Some Rastafarians are completely vegetarian. Some do not drink milk or coffee.

Buddhism – Buddhists will mostly be vegetarian. Meals will vary considerably, depending upon their country of origin.

Judaism – Many Jews will ask for Kosher food, i.e. meat that has been prepared in a special way according to Jewish law. Shellfish, pork, rabbit and derivatives are strictly prohibited (treifa foods). Milk and meat products are not eaten in the same meal. This means that they do not have milk in their drinks or cream with their desserts after their meat meal and do not use butter on meat sandwiches.

3.2.8 Price

Prices for fryers are set by the processors and tend to fluctuate only slightly during the year (McNitt, 1994). Jacobs (2000) and Hoffmann, Kobling, Stier and Gall (1992) found that higher prices of rabbit compared to other meats is a limiting factor in the marketing of rabbit meat. Green (1999) suggests that the producer should test the market before investing large amounts of money. He estimated the cost of producing a rabbit at R7.00, while the price of a dressed rabbit was R11-R14/kg in South Africa. The live rabbits were sold to local black communities at R16/kg in South Africa. According to Dalle Zotte (2002) the cost of production, which includes processing and the quality control are the most important determinants

for economically viable and marketable production. They determine the sales, profit and further production. Dalle Zotte (2002) further argues that the fact that there is less production of rabbit meat in developed countries compared to other meats is attributed to feeding costs that are very expensive and not being easy to reduce the production costs. The production costs of rabbits are twice as high as for broilers and they are 20-30% higher than for pigs. This implies that rabbit meat consequently becomes more expensive than other white meats. As a result its consumption is automatically decreased.

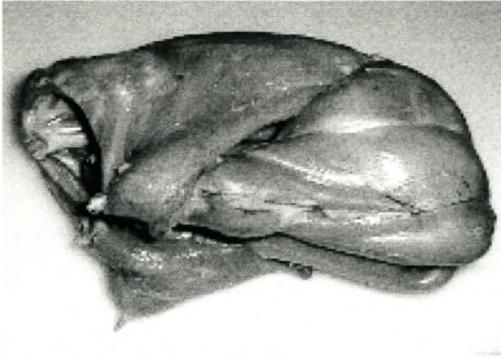
Dalle Zotte (2000) notes that the trend for selling rabbit meat in cuts or pre-cooked is increasing and this increases the price as well. However, consumers do not hesitate to pay higher prices due to the busy life styles of today. Apart from its convenience to the housewife, the other reason for the popularity of cut-up rabbit carcass in the package is the fact that it adds more profit per portion than the whole carcass. The most powerful tool for butchers is to obtain rabbits of a better conformation, with increased meat yields and appreciated production traits, while adjusting the pricing system (Jacobs, 2000).

3.2.9 Presentation

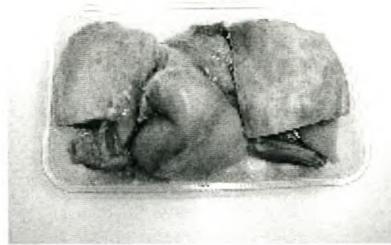
Rabbit meat can be marketed as whole, half or quarter animals as well as in packaged cuts (Born, 2000) as illustrated in Figure 3. The meat is presented in different ways in different countries. Traditionally in Italy and certain African countries, rabbits for the market are simply bled and gutted. In France until recently the carcasses were sold skinned, with the thoracic viscera, liver and kidneys, and the head and paws still covered with fur. This changed in 1980 and now the paws must be removed. The study conducted by Sonandi et al. (1996) revealed that in South Africa a large number of consumers of rabbit meat (79%) do not like rabbit meat to be presented as a whole carcass as it resembles a cat or a human infant. Kohlen et al. (2002) reveal that although rabbit used to be commercialised as a whole carcass, a trend of selling rabbit in retail cuts is developing.

Most of the stores will request a preference for fresh rabbit meat over frozen. This entails having to deliver the processed meat as quickly as possible after processing, since the stores rely heavily upon the ability to display the fresh product in the meat cases. Fresh rabbits under refrigeration have approximately a 6-day shelf life. Rabbit meat not on display will be frozen and thawed as needed (Sandford, 1986, Lamar, 1998). However freezing dries out the meat and causes it to lose some of its flavour. To overcome this condition the rabbit meat pieces should be arranged in appropriate packaging and be sealed before being frozen.

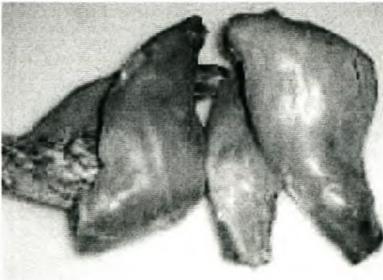
Labels must be specific in that they must clearly state the name of the product. For example, rabbit meat must carry basic cooking and storing instructions and must also state the name of the processing plant (Kohlen et al., 2002). Mary Carr (in Billett, 1999 and Baldo, 1999) has a strong feeling that a lot has to be done on the marketing of rabbit meat in South Africa, in particular on the presentation of the carcass. Mary Carr packages portions of the carcass together with the liver and kidneys wrapped separately in a container with recipes on the back.



Baron of Rabbit – whole Rabbit



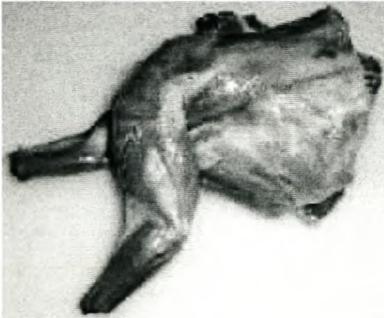
Portion pack-5 Pieces of Rabbit



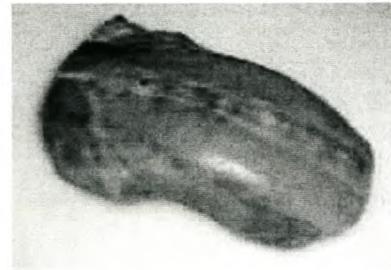
Bone-in legs



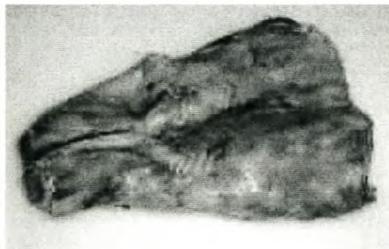
Boneless legs



Rabbit shoulder/ Two front legs



Saddles, bone-in,



Boneless leg fillet



stew and casseroles

Figure 3 Commercial cuts for rabbit meat (<http://www.woldsway.co.uk/index.htm>)

3.3 Places to sell rabbit meat

Green (1996) asserts that marketing of the meat is the most important part of farming rabbits and is the most difficult and time consuming. According to McNitt (1994) large, well-established markets for rabbits and rabbit products are very scarce, so locating places for the sale of rabbit meat and its products is still a problem. It is therefore essential for the rabbit farmer to establish a market for the product before starting the business. This is because a family can consume the production from a small rabbitry, but larger enterprises require a consistent, year-round market to be successful (Arrington & Kelly, 1976).

Chain-stores are often able to buy from local growers, so long as the meats have been processed in the appropriate facility. Others require that providers sell directly to their own regional distributors, which requires large quantities for providing all the stores in that chain for that region. Unless a grower has abundant fryers and an ample year-round surplus, it is not advisable for the independent processor to consider selling to a chain or individual distributor. Some chain stores, however, require only that the grower contact the main headquarters of the chain in order to establish a contract for the specific store. It never hurts to check (FAO, 1999).

3.4 Possible problems in rabbit meat marketing

Carr (in Gittens, 2000) points out that some producers fail to continue with the production of rabbit meat due to the fact that they get into the business with very high expectations of profit which is not normally the case for beginners. Nyete (in Gittens, 2000) adds that the rabbit industry, like any other business, has ups and downs. The underlying factors include input of top-level management, establishing a market, as well as a great deal of work. Experience from the running of a 600-doe meat farm, is that rabbit farming is more expensive to run at a large scale and will never be in the position to compete with poultry (Billy David in Gittens, 2000).

Marketing is a serious problem, as large chain stores insist on a constant flow of production and demand is difficult to meet due to fluctuation (FAO, 1999). Most producers do not produce enough rabbits to supply a processor and must market their fryers through some sort of cooperative agreement with other producers and the processor(s) of live rabbits. This has led to meat processors having a tendency of moving in and out of business (McNitt, 1994), so it is important to have more than one outlet available. However the most important part in the production for marketing is for the producer to be loyal and supply products on a continuous basis. Summer production is often overstocked, mainly due to the fact that it is the time when the market for meat is very weak (McNitt, 1994).

3.5 Conclusions

A greater number of consumers are aware of the possible health hazards associated with excess fat in meat. This phenomenon has increased the demand for lean meat in the human diet and thereby placing more pressure on the meat industries to produce meat that will satisfy consumers' needs. Generally health, taste and convenience are the major factors affecting changes in the marketing and consumption of meat. The literature further reflects that cut-up carcasses and pre-processed portions continue to gain an ever increasing share of the market.

Although a greater number of South Africans do eat a variety of meats, performance of rabbit meat production and marketing is still not well established, due to major constraints identified in the literature as:

- Associating rabbits with pets, and not meat-producing animals.
- Limiting the consumption of rabbit meat to the rural and the elderly urban population.
- Relating rabbit meat with meat of an unclean animal in the case of certain religious beliefs.
- Attaching a number of cultural beliefs, which forbid the consumption of rabbit meat that are related to colour of eyes and colour of fur.
- Above all, a lack of knowledge about the benefits of rabbit meat explains the limited marketing success of this product.
- Fluctuations in the market
- Unrealistic price expectations

Dissociating the product image from the image of the animal is therefore likely to be a challenge and should constitute one of the principal guidelines for a marketing strategy. The literature also shows that certain policies should be adopted in order to change the perceptions of the young about rabbit meat.

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CHAPTER 4

Comparison of growth rate, feed efficiency, carcass components and portion yields of two rabbit breeds.

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Abstract

Growth performance, feed efficiency and carcass components yield were determined by comparing two types of rabbit breeds (California and hybrid = Dutch red X California). Within the same experiment 5 rabbits of each breed were slaughtered at intervals of two weeks throughout the entire period (9-17 weeks), in order to evaluate the effect of age on these meat quality traits. The linear growth curve did not differ between the two breeds, and the linear trend accounted for 92% variance. While the live weight, slaughter weight, dressing percentage and skin weight increased with age, percentages of full gastrointestinal tract, liver and head decreased. The head weight for hybrid was significantly higher ($p < 0.05$) than for the California breed except at 11-weeks of age. But California breed had significantly higher values ($p < 0.05$) of skin weight than hybrid at 9, 13 and 17-weeks of age. The feed conversion ratio (kg feed/kg body weight) was generally high for both breeds but showed improvement with increase in age (from 13 to 6). Total saleable meat and meat yield percentage increased with age. The significant differences between breeds showed that California breed had more meat than hybrid (age 9, 11 and 17), thus the mean value for meat yield of the California breed was higher (29.2%) than that of the hybrid (27.5%). The general observation was that there were differences in the breed performances with the exception of growth rate. California breed had better carcass component yields than the hybrid. It was shown that delaying the slaughter age of rabbits, results in the improvement of valuable carcass components and consequently more saleable meat and total percentage of meat yield than for young ones.

Keywords: Two rabbit breeds (California and hybrid = Dutch red X California); growth performance; feed conversion ratio; carcass yield

4.1. Introduction

Over the past few years South Africa has experienced loud and persistent calls to breed rabbits for family consumption and for commercial purposes (Gittens, 2000). In response, the South African government established the Ciskei Rabbit Production Corporation to encourage small-scale rabbit farming in the Eastern Cape and to provide local communities with inexpensive meat. Unfortunately, the Corporation does not seem to have progressed at the anticipated rate, the major obstacle being lack of knowledge about the benefits of rabbit meat. Sonandi, Masika & Van Averbek (1996) also identified other major factors affecting rabbit meat production in South Africa, namely poor quality feed and lack of rabbit abattoirs.

Rabbit meat production is an effective way to ensure food security around the world (FAO, 1999). This is because it is considered a relatively simple enterprise in that rabbits can convert low quality feed into good meat thus becoming more economical than other domesticated animals. Rabbits also multiply rapidly and are ready to slaughter within a short period of time (Nyete as cited by Gittens, 2000).

Although rabbit breeding may seem simple, there are many crucial factors to consider before one starts breeding (Fourie, 1999). According to Eady and Prayaga (2000) one of the first questions a rabbit farmer asks is which breed of rabbit is best? Billet (1999) noted that selecting and purchasing the best rabbits for the meat project is the most important part of the business because the success of the entire operation is based on the type of breed. The breed should exhibit desirable characteristics such as healthiness, fast-growing progeny from the parent stock, live weight, have the largest litter size and good feed conversion ratios. The breeder should strive to find suitable breeding stock. However, there is a general feeling amongst rabbit breeders that South Africa does not have good quality breeds.

The most favoured rabbit meat breeds in South Africa are New Zealand Whites, Californians and Flemish Giants. New Zealand White and California breeds are medium-sized breeds that mature earlier than large breeds. These breeds mature at 1.8-2 kg in two months, they reach 2.5 kg in three months, 3.0-3.4 kg in four months and 3.6-3.9 kg in five months. They produce large litters that yield good quality meat. Although giant breeds are also used for meat, they have a less profitable feed:meat conversion ratio than medium breeds. They also have a meat:bone ratio that is not favourable because large breeds have bigger bones. One other factor of importance in the choice of breed is that white rabbits seem to be desired more than the coloured rabbits by commercial rabbit processing plants (Schoenian, 1998).

Growth rate is of economical importance to a commercial breeder for the simple reason that if animals have to be fed for a longer period of time before reaching the market weight, it will not be economical for the breeder (McNitt, 1994). Rapid increase in adult weight gain may result in negative effects such as less mature animals at slaughter, particularly if the slaughter live weight is fixed (Gomez et al., 1998). Growth rate also determines the feed efficiency in the post-weaning growth period, which is the main economic point of concern for commercial purposes (Feki et al., 1996). Gondret et al. (2002) found that the main

carcass traits such as dressing out percentage, muscle mass proportion, carcass drip loss and pH were not affected by growth selection. Corino et al. (1999) and Piles et al. (2000) showed however, that the live weight, carcass weight and dressing percentage increased significantly with age. In addition, carcass yield is also directly related to the weight and age of the animal.

Taking into account all of the above mentioned-points, there is a strong need to make the right choice of breed in the rabbit meat industry to reduce production costs, improve dressing out percentage and to supply consumers with tender meat. The main objective of this study was therefore to compare the two rabbit breeds (California and hybrid = Dutch Red X California) in terms of growth rate, feed conversion ratio and carcass yields.

4.2. Materials and methods

4.2.1. Animal and housing

The experiment was conducted at the experimental farm of Stellenbosch University. The differences in two breeds were determined in terms of feed intake, growth rate, carcass yield and composition. A total number of 50 rabbits from two breeds (25/breed) were used in the experiment. The two breeds were California and hybrid (cross between Dutch red and California). The rabbits were purchased at the age of 8 weeks from two rabbit farms in the Western Cape. On arrival the rabbits were marked and weighed. The average initial weight recorded was 1 kg with a range of 0.93 kg – 1.4 kg for both breeds. The 25 rabbits of each breed were randomly allocated to individual cages inside the rabbit house that was equipped with a fan to ensure coolness on hot days. During the fattening period the average environmental temperatures ranged between 26-37°C. Each cage had a metallic feeder suspended at a reasonable height in front of the cage and an automatic nipple water supply system inside the cage.

4.2.2. Diet

During the entire fattening period which lasted for 9 weeks, each animal had free access to a commercial pelleted diet from *Bokomo* feeds containing 160 g protein, 150 g fibre, 120 g moisture, 25 g fat, 8 g calcium and 3.5 g phosphorus per kilogram. The intake of feed was recorded daily for each rabbit by weighing amounts offered and refused. The feeders were cleaned of any urinated food material as the need arose.

4.2.3. Growth Rate and Feed Efficiency

The growth patterns of the rabbits were determined by weighing them individually on the seventh day of every week (Body weight). Ideally, weighing rabbits regularly gives an indication of weight changes, from which observed unexpected weight loss can be an indication of illness (Fielding, 1991). Rabbits were weighed by placing them inside a box on a pan-scale.

To determine feed consumption ratio (FCR) the following calculations were made: Total feed consumption (FC) = Feed allocated – feed remaining. While the feed conversion ratio (FCR) = total feed intake/total weight of rabbits.

4.2.4. Slaughtering

The rabbits were slaughtered after fasting for 24 h. However during this time they had access to water. The slaughtering was performed at the Meat Science Laboratory in the Animal Science Department of the University. This process took place over the entire experimental period at intervals of two weeks at 9, 11, 13 (commercial slaughter age), 15 and 17 (sexual maturity) weeks of age (n=5 per breed/per period). The live weight of rabbits was recorded prior to slaughtering (slaughter weight). Rabbits were slaughtered according to the national regulations applied to the commercial slaughtering of rabbits. Thereafter, the carcasses were prepared according to the procedure described by Blasco et al. (1993). This included removing the blood, skin, distal parts of the tail, fore and hind legs, gastrointestinal and urogenital tracts. The head, liver, lungs, heart and kidneys were also removed.

4.2.5. Carcass components

The following variables were measured to facilitate the calculations, which determine the carcass yield: Live weight (LW), slaughter weight (SW), full gastrointestinal tract weight (FGTW), skin weight (SkW), head weight (HW), liver weight (LvW), weight of kidneys (KiW), weight of a set of organs consisting of the thymus, trachea, oesophagus, lung and heart (LHW), hot carcass weight (HCW). After weighing these components the carcasses were then stored at 2-4 °C for 24 h. After 24 h the chilled carcass weight (CCW), was recorded.

The carcass was then cut according to the cut points illustrated by Blasco et al. (1993). Cut point 1: between the 7th and 8th thoracic ribs, following the prolongation of the ribs when cutting the thoracic wall, cut point 2: between the last dorsal and the first lumbar vertebrae, following the prolongation of the 12th ribs when cutting the thoracic wall, cut point 3: between the 6th and 7th lumbar vertebrae cutting the carcass and the abdominal walls transversally to the vertebral column and cut point 4: fore legs including the insertion and thoracic muscles. The retail cuts were then measured and individually weighed after which the following formula was used to calculate the dressing out percentage and the percentage of every portion. Dressing out percentage = chilled carcass weight/slaughter weight X 100, portion yield = portion weight/chilled carcass weight X100.

The legs, chest and shoulders were then deboned. The following variables were measured after deboning: meat weight of hind legs, bone weight of hind legs meat weight of fore legs, bone weight of fore legs, meat weight of chilled carcass, bone weight of the chilled carcass, *longissimus dorsi* meat weight, *longissimus dorsi* bone weight. Calculations were performed as follows: % meat portion yield = deboned meats yield/live weight X 100, total saleable meat = hind leg meat + fore leg meat + breast meat. % meat yield = total saleable meat/live weight X 100 and meat:bone ratio (M:B) = meat weight/bone weight X 100. For the purpose of this study only these three portions were deboned. Other cuts of the rabbit carcass were not deboned. As a result their meat could not be included in the final calculation.

4.2.6. Statistical analysis

A two factor factorial experiment was performed in a completely randomised design with 5 random replications. The factors were 2 breeds (California and hybrid). An experimental unit was a single carcass. The variables were recorded as interval data and subjected to an analysis of variance (ANOVA) using SAS version 8.2 (SAS, 1999) statistical software. The Shapiro-Wilk test was performed to test for non-normality (Shapiro & Wilk, 1965). Statistical significant differences were established at the 5% confidence level to compare treatment means (Ott, 1998).

4.3. Results and discussions

The findings of the study with regard to the growth rate, feed conversion ratio and meat quality traits (carcass components yield) of the two rabbit breeds are discussed below.

4.3.1. Growth rate

The initial mean weight of the rabbits at 8 weeks was 1.2 kg for both breeds. The body weight of both rabbit breeds increased linearly until the final weight of 3.2 kg and 3.3 kg for California and hybrid respectively (Figure 1 and Table 1). Although there were no major differences between these two breeds regarding weight gain, California rabbits were slightly heavier than their counterparts (hybrid) at the beginning of the experiment up until the tenth week. A slight difference was observed again as the trial proceeded (from 11-17 weeks) with the hybrid gaining more weight than the California breed. According to Fielding (1991) and Sandford (1986), the growth curve of rabbits is no different from the typical animal growth curve that results in an S-shaped curve when weight is regressed against age.

Table 1

Effect of age on growth performance, carcass characteristics, feed conversion ratio and dressing percentage of two rabbit breeds

Traits	Slaughter Age (weeks)				
	9	11	13	15	17
Final body weight (g)					
CB	1448.2±0.03 ^e	1922.7±0.04 ^d	2375.6±0.06 ^c	2799.7±0.07 ^b	3192.2±0.13 ^a
HB	1405.6±0.04 ^e	1928.1±0.04 ^d	2377.2±0.05 ^c	2830.7±0.06 ^b	3303.2±0.14 ^a
Slaughter weight (g)					
CB	1160.6±18.05 ^e	1604.8±22.10 ^d	2162.9±8.87 ^c	2514.2±14.68 ^b	3060.41±3.86 ^a
HB	1059.6±23.63 ^e	1577.6±13.49 ^d	2110.0±23.0 ^c	2571.4±31.86 ^b	3132.63±0.56 ^a
Daily feed intake (g/d)					
CB	221.3±3.24 ^a	175.9±2.01 ^b _A	152.1±1.36 ^c _B	121.3±0.46 ^d _A	149.2±0.33 ^e _A
HB	221.8±2.88 ^a	152.5±0.69 ^b _B	161.5±2.93 ^c _A	92.8±0.27 ^d _B	142.4±0.21 ^d _B
Daily weight gain (g/d)					
CB	30.5±0.07 ^a	24.2±0.14 ^b	29.0±0.06 ^b	20.0±0.02 ^c	15.4±0.02 ^c
HB	29.8±0.24 ^a	28.8±0.87 ^{ab}	27.1±0.03 ^c	24.5±0.29 ^c	24.1±0.06 ^d
Feed conversion ratio					
CB	7.26±0.55 ^a	7.27±0.57 ^{ab} _A	5.24±0.14 ^c _B	6.07±0.39 ^{cd} _A	9.69±0.39 ^d _A
HB	7.44±0.57 ^a	6.09±0.31 ^b _B	5.97±1.06 ^c _A	3.78±0.21 ^e _B	5.9±0.04 ^d _B
Hot carcass weight (g)					
CB	572.4±3.28 ^e	848.2±5.92 ^d	1163.7±8.27 ^c	1422.2±4.01 ^b	1697.9±6.55 ^a
HB	476.0±8.44 ^e	796.6±8.28 ^d	1192.4±8.50 ^c	1432.4±0.34 ^b	1648.1±1.02 ^a
Chilled carcass weight (g)					
CB	516.6±2.85 ^e	813.2±5.43 ^d	1124.1±7.77 ^c	1373.8±3.87 ^b	1644.7±3.55 ^a
HB	422.8±6.82 ^e	761.8±6.92 ^d	1140.4±0.57 ^c	1393.0±9.53 ^b	1722.7±3.36 ^a
Dressing out percentage (%)					
CB	44.5±1.57 ^d _A	50.7±1.00 ^c _A	52.1±1.16 ^b _B	54.6±0.58 ^a _A	53.7±0.38 ^{ab} _A
HB	39.9±0.82 ^d _B	48.3±0.79 ^c _B	54.1±0.25 ^a _A	54.2±1.09 ^a _A	52.6±0.72 ^b _B
Dressing percentage (%)					
CB	49.3±1.50 ^c _A	49.3±1.50 ^c _A	53.9±0.73 ^a _B	56.6±0.61 ^a _A	55.5±0.43 ^a _A
HB	45.0±0.99 ^c _B	50.5±0.87 ^b _A	56.5±0.35 ^a _A	55.7±1.11 ^a _A	54.9±0.41 ^a _B

^{a-e}Means in the same row with different superscript letters are significantly different (p<0.01)_{A-B}Means in the same column, within traits with different subscript letters are significantly different (p<0.05)

± SD for 5 samples from each breed at different slaughtering.

CB = California breed

HB = Hybrid

Total number of rabbits decreased from 9 weeks (25) to 17 weeks (5) for each breed.

The results in Figure 1 show that these rabbits grew at an average of 30 g/d at 9 weeks of age and 15-24 g/d at 17 weeks of age. This rate of growth is lower than the rates reported by Fielding (1991), who reported that one-week-old rabbits grow at an average of 11 g/d while 6-7-week-old rabbits grow at average of 40 g/d. Similarly, Xiccato, Trocino, Sartori and Queaque (2002) noted an average growth rate of 42 g/d while Gondret, Combes, Larzul and Rochambeau (2002) reported 55.2 g/d weight gain for heavy rabbits and 50.6 g/d for light weight rabbits. The reasons for these differences may be due to the fact that rabbits used for the present study experiment were considerably older (8-17 weeks) and that they were fed commercial pelleted diet suitable for cattle and not well-balanced for rabbits. Fielding (1991) further noted that it is advisable to slaughter rabbits when they are about 8 weeks. The feed conversion efficiency is high until this age and thereafter it starts to decrease.

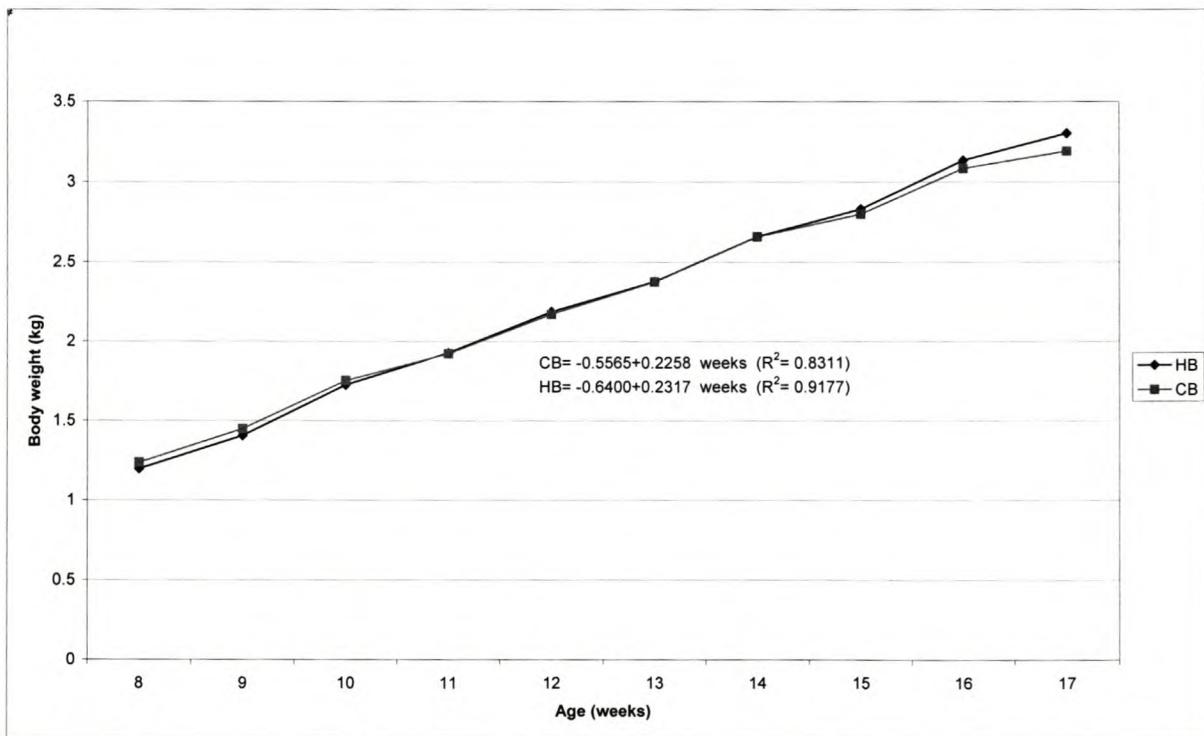


Figure 1
Weight gain of two rabbit breeds over nine weeks (8-17weeks)

4.3.2. Feed efficiency

The feed conversion ratios obtained from this experiment were higher (from 9.6-3.8) than the values reported in the literature (2.7, 3.24, 3-6) (Gondret et al., 2002, Sandford, 1986, Xiccato et al., 2002) (see Table 1). This can be explained by the fact that either too much food was wasted as a result of the poor quality metallic feeders used, or secondly, no formulated rabbit feed was available.

A balanced commercial rabbit diet could not be sourced in the region where the trial was conducted. The commercial producers from which the rabbits were purchased, indicated that this is a problem experienced throughout South Africa. This aspect warrants further research. As a result a calf starter feed (regularly used by rabbit producers) was used. This type of feed is not a balanced rabbit diet. According to the results in Table 1, the hybrid had a better feed conversion ratio at 11, 15 and 17 weeks (6.1, 3.8 and 5.9 g feed/g weight gain) versus that for California breed (7.3 and 6.1 and 9.7 g feed/g weight gain). The feed conversion ratio was the most efficient at 15 weeks of age for the hybrid, showing a more desirable ratio (3.8 g feed/g weight gain) than the California breeds (6.1 g feed/g weight gain).

4.3.3. Carcass yield

4.3.3.1 Dressing percentage

Age had a significant ($p < 0.01$) influence on the dressing percentage of the rabbits (Table 1). The lowest dressing percentages were recorded at 9 weeks for both breeds: California (49.3%) and hybrid (45.0%). A considerable increase was observed up to 17 weeks of age and an average of 55% was recorded for both breeds. The last three ages (13, 15 and 17 weeks) did not differ significantly ($P > 0.05$) from each other. These results are in line with the findings of Fielding (1991) who noted that dressing percentage of rabbit meat is around 50-56% and that as an animal gets older the dressing percentage remains constant or decreases. Recent research demonstrated that at a younger age and at a lower body weight, there is a more rapid increase in dressing percentage than in older heavier rabbits (Szendro et al., 2002). However, it would be worthwhile to mention that in order to determine the dressing percentage in this experiment, the liver, heart and kidneys were not included in the carcass weight as suggested by Fielding (1991). This could be one of the reasons explaining the lower results obtained from this study compared to the results reported by Szendro et al. (2002) regarding the effect of age and weight of rabbits on dressing percentage. Their rabbits at 10.5, 12 and 13.5 weeks of age, showed dressing percentages of 58.8%, 60.8% and 60.6% respectively. They also found that body weight had a highly significant ($p < 0.01$) effect on the dressing percentage. Therefore, the lower values from this study could also have resulted from the lower body weights of the rabbits.

The results of this study also revealed that the dressing percentage of the California breed was significantly higher than that of the hybrid at all ages of treatment (Table 1) except age 13 weeks where the hybrid showed a higher (56.5%) value than the California breed (53.9%). These results are in agreement with Fielding (1991) and Ireland (2001) that the dressing percentage varies with breed and age.

4.3.4. Yields of Carcass components

Table 2 illustrates the effects of age and breed on the measured carcass components, namely weights of full gastro-intestinal tract, liver, kidney, head, feet, lungs, skin and blood. It was found that age significantly

influenced ($p < 0.001$) anatomical composition with a slight difference in kidneys and lungs. In this study, a higher gastrointestinal tract weight (25%) was obtained at 9 weeks of age, while the lowest value (14.6%) was recorded at 17 weeks. Results of this study confirmed the findings reported by Gomez et al. (1998) that the ratio of full gastrointestinal tract weight to live weight decreases with age or maturity. The highest values for the gastrointestinal tract at a younger age may be explained by the higher daily feed intake at that age when compared to the older age (Table 1). According to Ouhayoun (1998) the diet has a marked effect on the relative development of organs and tissues and thus on anatomical carcass composition. The full gastrointestinal tract measurements showed some significant differences ($p < 0.05$) between breeds. Hybrid had the heaviest weight at 9, 11 and 13 weeks of age compared to the California breed.

Analysis of variance showed that there was a significant difference between ages ($p < 0.05$) regarding liver weight. The percentage liver decreased with an increase in age. This supports the statement by Gomez et al. (1998) that the liver is an early developing organ. In addition to this, Ouhayoun (1998) stated that the liver proportion increases up to an empty body weight of 1 500 g and then rapidly decreases. There was no significance difference ($p > 0.05$) for liver values between the two breeds. On the other hand, Butcher et al. (1981) noted that liver weights may differ as a result of diet/breed interaction.

The size of the head was significantly ($p < 0.05$) affected by the age of the rabbits with the head percentage decreasing as the body weight increased. These results are in agreement with the findings of Deltoro and Lopez (1986) (as cited by Gomez et al., 1998) that the head is an early developing organ. The present study also indicated the significant difference ($p < 0.05$) between breeds for the head weight. Hybrid showed the heaviest head weights compared to California throughout the entire experimental period. These results contradict those of Gomez et al. (1998) who noted that there were no differences for head weight percentages found between different rabbit breeds.

A similar pattern was observed with feet proportions to live weight. The proportions steadily decreased with increase in age (Table 2). However, the hybrid had significantly higher ($p < 0.05$) feet weights than California from 11 weeks to 17 weeks.

An opposite trend was observed on the skin proportions to live weight. The percentages increased with an increase in age. An average of 11-12% was recorded at 9 weeks and 15-16% at 17 weeks for both breeds, but the higher values of California breed at 9, 13 and 15 weeks of age were significantly different from the values for hybrid.

The blood proportion was also significantly influenced by age ($p < 0.05$). Younger rabbits seemed to have higher proportion of blood than the older rabbits (Table 2). However, breed type did not have an influence on the blood weight of the rabbits ($p > 0.05$).

Table 2

Effects of age on the carcass components of two rabbit breeds (California (CB) & hybrid HB)) slaughtered at different ages

Carcass components	Breed	Weight (g) of slaughter age (weeks)					Proportions (% of liveweight) at slaughter age (weeks)				
		9	11	13	15	17	9	11	13	15	17
GTW	CB	279.0±13.2 ^a	303.2±12.9 ^d	370.4±11.2 ^c	377.6±17.1 ^b	444.6±16.1 ^a	24.0±0.1 ^a _B	18.9±0.7 ^b _B	17.1±0.4 ^c	15.0±0.7 ^{cd} _B	14.6±0.4 ^d
	HB	284.6±14.1 ^e	328.8±9.9 ^d	352.8±10.9 ^c	422.0±16.0 ^b	462.4±16.5 ^a	26.9±0.3 ^a _A	20.9±0.9 ^b _A	16.7±0.3 ^c	16.4±0.6 ^{cd} _A	14.7±0.3 ^{cd}
vW	CB	39.5±3.3 ^d	48.1±3.4 ^c	51.5±3.3 ^c	60.1±3.1 ^b	73.1±4.6 ^a	3.4±0.2 ^a	3.0±0.1 ^a	2.9±0.1 ^a	2.4±0.1 ^b	2.4±0.1 ^b
	HB	33.9±2.3 ^e	53.5±3.6 ^d	57.7±3.9 ^c	68.9±4.7 ^b	78.2±4.9 ^a	3.2±0.2 ^a	3.4±0.1 ^a	2.7±0.1 ^{ab}	2.7±0.1 ^b	2.5±0.1 ^b
iW	CB	10.9±0.6 ^d	17.5±1.2 ^c _A	20.6±0.9 ^b	20.8±0.7 ^b	28.7±1.7 ^a _A	0.9±0.1 ^b _A	1.1±0.1 ^a _A	0.8±0.1 ^{bc} _B	0.8±0.1 ^{bc}	0.9±0.1 ^b _A
	HB	8.2±0.4 ^e	13.1±0.6 ^d _B	17.7±0.5 ^c	22.2±0.8 ^b	24.5±1.6 ^a _B	0.8±0.1 ^c _B	0.8±0.1 ^c _B	0.9±0.2 ^a _A	0.9±0.1 ^b	0.8±0.1 ^c _B
HW	CB	17.4±1.2 ^e	20.5±0.7 ^d	19.2±0.6 ^c	27.9±1.5 ^b	38.3±0.9 ^a	1.5±0.1 ^a	1.3±0.1 ^{ab}	1.1±0.1 ^c	1.1±0.1 ^c	1.3±0.1 ^{ab}
	HB	12.7±0.7 ^e	20.9±0.9 ^d	25.0±1.9 ^c	28.4±1.6 ^b	33.6±2.7 ^a	1.2±0.1 ^b	1.3±0.1 ^a	1.2±0.1 ^b	1.1±0.1 ^{bc}	1.1±0.1 ^c
W	CB	71.2±1.6 ^e _B	94.0±2.2 ^d _A	115.1±2.3 ^c _B	126.2±3.5 ^b _B	149.2±4.3 ^a _B	6.1±0.2 ^a _B	5.9±0.1 ^b _A	5.4±0.1 ^b _B	5.0±0.2 ^b _B	4.8±0.1 ^c _B
	HB	76.9±1.9 ^e _A	94.5±2.3 ^d _A	126.2±1.7 ^c _A	144.8±4.6 ^b _A	154.4±4.5 ^a _A	7.3±0.3 ^a _A	6.0±0.1 ^b _A	5.5±0.2 ^b _A	5.6±0.2 ^b _A	5.0±0.1 ^c _A
W	CB	38.6±1.1 ^d _A	50.6±1.6 ^c _B	49.4±1.0 ^c _B	60.2±5.8 ^b _B	65.2±6.8 ^a _B	3.3±0.1 ^{ab}	3.2±0.1 ^b _B	2.6±0.1 ^{bc} _A	2.4±0.1 ^c _B	2.1±0.1 ^{cd} _B
	HB	37.0±0.8 ^d _A	53.4±2.1 ^c _A	51.8±1.3 ^c _A	73.0±4.3 ^b _A	84.0±7.6 ^a _A	3.5±0.1 ^a _A	3.4±0.1 ^b _A	2.5±0.1 ^d _B	2.8±0.1 ^c _A	2.7±0.1 ^c _A
kW	CB	149.4±3.6 ^e	235.4±6.5 ^d	319.4±12.9 ^c	413.0±14.4 ^b	488.0±16.2 ^a	12.9±19.3 ^d _A	14.7±16.7 ^{bc} _A	15.2±0.3 ^b _A	16.4±18.2 ^a _A	16.0±22.4 ^{ab} _A
	HB	118.4±2.4 ^e	232.4±6.4 ^d	298.2±11.8 ^c	392.0±18.0 ^b	495.8±16.6 ^a	11.2±18.9 ^d _B	14.7±16.4 ^{bc} _A	14.2±0.3 ^b _B	15.3±16.7 ^b _B	15.9±18.18 ^a _A
IW	CB	33.6±1.1 ^d	27.8±4.6 ^e	42.1±2.5 ^c	50.8±1.9 ^b	73.6±4.1 ^a	2.9±0.3 ^a	1.7±0.3 ^d	1.9±0.1 ^d	2.0±0.1 ^c	2.4±0.2 ^b
	HB	38.2±0.9 ^{cd}	25.6±4.2 ^e	52.6±3.4 ^{bc}	45.8±1.7 ^c	61.0±2.9 ^a	3.6±0.1 ^a	1.6±0.3 ^d	2.5±0.2 ^b	1.8±0.1 ^{cd}	2.0±0.2 ^c

Effects of age on anatomical composition: slaughter weight (SW), full gastrointestinal tract weight (FGTW), liver weight (LvW), kidney weight (KiW), head weight (HW), blood weight (BIW), feet weight (FW), set of lungs, heart, thymus, oesophagus and trachea (LHW), skin weight (SkW).

^{a-e} Different letters in the same row with different superscripts indicate significant differences ($p < 0.05$).

_{A,B} Means in the same column, within carcass components with different subscript letters are significantly different from each other ($p < 0.05$)

5 samples from each breed at different slaughtering periods.

4.3.5. Carcass and portion yield

4.3.5.1 Hind leg

The carcass traits of the rabbits were significantly affected ($p < 0.05$) by age (Table 3). The hind leg increased proportionately as the rabbits became older. However, no significant differences were observed between 13 and 17 weeks of age when the hind leg was expressed as a proportion of the live weight. These results do not support those of Szendro et al. (2002) who noted that the hind part of the carcass showed a considerable decrease ($p < 0.01$) as the age increased. There were no significant differences ($p > 0.05$) between breeds, the California were heavier for the total hind leg weights or for the hind leg meat or bone proportions. The proportions of meat in the hind leg portion increased with age whilst the proportion of bone tended to either remain constant or decrease (Table 3).

4.3.5.2 Fore leg

Fore leg percentage yield seemed lower than other carcass portions. However, with increasing age there was a significant increase ($p < 0.01$) in this portion (Table 3). The increase in the proportion of the fore leg was significant at younger ages (9 to 13 weeks), and increased considerably at 17 weeks. Thus, heavier rabbits yielded higher proportions of fore leg, a result similar to that noted by Szendro (2002). Breed effects were not significant in fore leg yield ($p > 0.05$), although significant differences were observed ($p < 0.05$) between breeds, as pertaining to the meat yield of the fore leg. The California breed yielded more fore leg meat than the hybrid (Table 3).

4.3.5.3 Chest portion

The chest portion yield was significantly affected by age ($p < 0.01$) showing the lowest proportions at a younger age than at older ages. The general increase in proportion of the chest portion (Table 3) may be explained by a well known factor that as age increases the body weight consequently increases. In this regard Szendro (2002) noted that body weight has more effect on the intermediate part than age. California had the higher proportions of chest portion than hybrid except at age 9 and 13 weeks, but breed differences were not significant ($p > 0.05$). The significant differences were observed as pertaining to the meat yield in this portion.

4.3.5.4 Total saleable meat

Table 3 shows the total saleable meat derived from the rabbit carcasses. Significant differences ($p < 0.05$) between ages for total saleable meat were observed in this study. The total saleable meat of rabbits followed a similar trend (increase with age). The California breed had significantly higher total saleable meat than hybrid at 9, 11 and 17 weeks of age. Significant differences were also noted in meat yield ($p < 0.05$) between breeds. California breed yielded more meat than the hybrid. However, at 9, 13 and 15 weeks breed did not affect the meat yield.

Table 3

Effects of age and breed on the carcass portions of rabbits (California breed & hybrid) slaughtered at different stages of maturity

Traits	Weight (g) at slaughter age (weeks)					Portions (% of liveweight) at slaughter age (weeks)					
	Age	9	11	13	15	17	9	11	13	15	17
Hind leg portion	CB	199.8 [±] 7.0 ^e	299.0 [±] 7.3 ^d	392.7 [±] 8.0 ^c	484.0 [±] 5.7 ^b	583.4 [±] 15.2 ^a	17.2 [±] 0.4 ^c _A	17.5 [±] 0.3 ^b	19.3 [±] 0.2 ^a	19.3 [±] 0.2 ^a	19.1 [±] 0.2 ^a
	HB	165.6 [±] 1.0 ^e	276.0 [±] 9.4 ^d	407.0 [±] 10.9 ^c	500.4 [±] 4.8 ^b	583.8 [±] 28.5 ^a	15.7 [±] 0.4 ^c _B	17.5 [±] 0.5 ^b	19.3 [±] 0.4 ^a	19.5 [±] 0.2 ^a	18.6 [±] 0.2 ^{ab}
Hind leg meat	CB	152.2 [±] 7.4 ^e _A	233.2 [±] 6.6 ^d _A	305.4 [±] 2.6 ^c	376.0 [±] 5.8 ^b	483.2 [±] 5.3 ^a	13.1 [±] 0.4 ^d _A	14.5 [±] 0.3 ^c _A	14.8 [±] 0.3 ^b	14.9 [±] 0.3 ^a	15.8 [±] 0.2 ^a
	HB	120.6 [±] 1.1 ^e _B	205.8 [±] 7.0 ^d _B	308.0 [±] 1.5 ^c	386.0 [±] 4.6 ^b	487.0 [±] 8.4 ^a	11.4 [±] 0.3 ^d _B	13.0 [±] 0.4 ^c _B	14.60.5 ^b	15.00.2 ^a	15.5 [±] 0.3 ^a
Hind leg bone	CB	47.6 [±] 1.8 ^e	65.8 [±] 0.8 ^d	87.3 [±] 3.7 ^c	108.0 [±] 2.2 ^a	100.2 [±] 2.8 ^b	4.1 [±] 0.1 ^b	4.2 [±] 0.1 ^b	4.5 [±] 0.2 ^a	4.3 [±] 0.0 ^{ab}	3.3 [±] 0.1 ^c
	HB	45.6 [±] 0.8 ^e	70.0 [±] 2.7 ^d	97.8 [±] 3.6 ^c	114.4 [±] 1.3 ^a	96.8 [±] 3.9 ^d	4.3 [±] 0.2 ^{bc}	4.4 [±] 0.13 ^b	4.6 [±] 0.1 ^a	4.4 [±] 0.0 ^b	3.1 [±] 0.2 ^c
Fore leg portion	CB	81.8 [±] 3.8 ^e	117.8 [±] 2.8 ^d	179.7 [±] 3.1 ^c	209.0 [±] 4.4 ^b	309.6 [±] 12.1 ^a	7.0 [±] 0.3 ^c	7.2 [±] 0.13 ^c	8.4 [±] 0.2 ^b	8.3 [±] 0.2 ^b	10.1 [±] 0.3 ^a
	HB	69.6 [±] 2.4 ^e	112.6 [±] 5.6 ^d	159.2 [±] 5.9 ^c	209.0 [±] 3.6 ^b	281.6 [±] 13.9 ^a	6.6 [±] 0.4 ^c	7.3 [±] 0.1b ^c	7.1 [±] 0.2 ^b	7.6 [±] 0.3 ^b	9.0 [±] 0.3 ^a
Fore leg meat	CB	63.2 [±] 4.5 ^e _A	93.4 [±] 5.0 ^d	145.9 [±] 3.6 ^c _A	166.8 [±] 3.4 ^b	269.4 [±] 7.7 ^a _A	5.4 [±] 0.2 ^d _A	5.8 [±] 0.1 ^c	6.6 [±] 0.2 ^{bc}	6.6 [±] 0.2 ^b _A	8.8 [±] 0.4 ^a _A
	HB	50.4 [±] 3.4 ^e _B	87.8 [±] 1.3 ^d	124.2 [±] 2.9 ^c _B	161.8 [±] 7.9 ^b	234.2 [±] 3.7 ^a _B	4.8 [±] 0.3 ^d _B	5.6 [±] 0.1 ^c	5.9 [±] 0.1 ^{bc}	6.3 [±] 0.3 ^b _B	7.5 [±] 0.4 ^a _B
Fore leg bone	CB	18.6 [±] 1.2 ^d	24.4 [±] 0.2 ^c	38.4 [±] 2.1 ^b _A	42.2 [±] 0.9 ^b _B	40.2 [±] 2.8 ^a _B	1.6 [±] 0.1 ^b _B	1.5 [±] 0.03 ^c	1.8 [±] 0.0 ^a	1.7 [±] 0.0 ^a	1.3 [±] 0.1 ^c _B
	HB	19.2 [±] 0.8 ^d	24.8 [±] 0.6 ^c	35.6 [±] 1.1 ^b _B	47.2 [±] 0.8 ^a _A	47.4 [±] 3.6 ^a _A	1.8 [±] 0.4 ^a _A	1.6 [±] 0.03 ^c	1.7 [±] 0.1 ^b	1.8 [±] 0.0 ^a	1.5 [±] 0.1 ^d _A
Chest portion	CB	48.6 [±] 3.9 ^e	164.0 [±] 7.7 ^d	233.3 [±] 9.4 ^c	276.8 [±] 9.0 ^b	337.6 [±] 17.1 ^a	4.2 [±] 0.3 ^d	10.2 [±] 0.3 ^c	11.4 [±] 0.4 ^a	11.0 [±] 0.3 ^a	11.0 [±] 0.3 ^b
	HB	53.8 [±] 1.4 ^e	142.6 [±] 4.3 ^d	245.0 [±] 8.9 ^c	269.4 [±] 17.4 ^b	315.0 [±] 21.3 ^a	5.1 [±] 0.2 ^d	9.0 [±] 0.3 ^c	11.6 [±] 0.4 ^a	10.5 [±] 0.7 ^{ab}	10.0 [±] 0.5 ^b
Chest meat	CB	32.4 [±] 2.9 ^e	138.4 [±] 6.9 ^d	190.4 [±] 5.6 ^c	230.4 [±] 7.4 ^b	288.2 [±] 4.3 ^a	2.8 [±] 0.2 ^c _B	8.6 [±] 0.4 ^b	9.2 [±] 0.4 ^a	9.2 [±] 0.3 ^a	9.4 [±] 0.3 ^a
	HB	37.8 [±] 1.0 ^e	113.8 [±] 4.6 ^d	207.2 [±] 8.8 ^c	224.2 [±] 16.4 ^b	267.0 [±] 7.3 ^a	3.6 [±] 0.2 ^d _A	7.2 [±] 0.3 ^c	9.8 [±] 0.4 ^a	8.7 [±] 0.6 ^b	8.5 [±] 0.4 ^b
Chest bone	CB	16.2 [±] 0.6 ^d	25.6 [±] 2.3 ^c	41.5 [±] 3.1 ^b	46.4 [±] 1.8 ^a	49.4 [±] 3.0 ^a	1.4 [±] 0.1 ^c	1.6 [±] 0.1 ^b	1.7 [±] 0.1 ^{ab}	1.9 [±] 0.4 ^a	1.6 [±] 0.1 ^{bc}
	HB	16.0 [±] 0.9 ^d	28.8 [±] 0.7 ^c	36.4 [±] 1.8 ^b	45.2 [±] 1.3 ^a	48.0 [±] 5.1 ^a	1.5 [±] 0.1 ^c	1.8 [±] 0.1 ^a	1.7 [±] 0.1 ^b	1.6 [±] 0.5 ^{bc}	1.5 [±] 0.3 ^c
Meat Yield	CB	247.8 [±] 9.4 ^e _A	465.0 [±] 13.4 ^d _A	639.4 [±] 13.6 ^c	773.2 [±] 13.9 ^b	1040.5 [±] 3.5 ^a _A	21.4 [±] 0.6 ^d	29.0 [±] 0.7 ^c _A	30.6 [±] 0.5 ^b	30.7 [±] 0.5 ^b	34.0 [±] 0.6 ^a _A
	HB	208.8 [±] 3.7 ^e _B	407.4 [±] 11.2 ^d _B	618.8 [±] 19.3 ^c	772.0 [±] 26.5 ^b	988.2 [±] 48.3 ^a _B	19.8 [±] 0.6 ^d	25.8 [±] 0.6 ^c _B	30.3 [±] 0.8 ^b	30.0 [±] 0.9 ^b	31.5 [±] 0.4 ^a _B

Table 3 (cont.)

		Weight (g) at slaughter age (weeks)				
		9	11	13	15	17
Muscle to bone ratio						
Hind leg	CB	3.19 [±] 0.1 ^c	3.55 [±] 0.1 ^b	3.55 [±] 0.2 ^b	3.48 [±] 0.0 ^b	4.83 [±] 0.2 ^a
	HB	2.65 [±] 0.1 ^c	2.94 [±] 0.1 ^{bc}	3.17 [±] 0.2 ^b	3.38 [±] 0.1 ^b	5.06 [±] 0.4 ^a
Fore leg	CB	3.40 [±] 0.2 ^c _A	3.86 [±] 0.3 ^b	3.79 [±] 0.3 ^b	3.96 [±] 0.1 ^b _A	6.79 [±] 0.5 ^a _A
	HB	2.61 [±] 0.1 ^c _B	3.54 [±] 0.1 ^b	3.49 [±] 0.0 ^b	3.42 [±] 0.1 ^b _B	5.07 [±] 0.6 ^a _B
Chest	CB	2.18 [±] 0.1 ^e	4.75 [±] 0.3 ^{cd}	4.92 [±] 0.3 ^b	4.96 [±] 0.1 ^b	5.78 [±] 0.7 ^a
	HB	2.14 [±] 0.1 ^e	4.65 [±] 0.2 ^c	4.89 [±] 0.2 ^{bc}	4.72 [±] 0.1 ^b	5.24 [±] 0.3 ^{ab}

^{a-e}Different letters in the same row indicate significant differences ($p < 0.05$)

_{A-B}Means in the same column, within a trait, with different subscript letters are significantly different from each other ($p < 0.05$)

[±] SD for 5 samples from each breed at different slaughtering periods.

4.3.5.5 Muscle:bone ratio

The muscle:bone ratio of all portions (hind leg, fore leg and chest) showed a significant increase ($p < 0.05$) with increase in age (Table 3) for both breeds. The results of this study are in line with the findings of Parigi-Bini et al. (1992) who found that the muscle:bone ratio increases with an increase in rabbit age. On the other hand, Ouhayoun (1998) stated that between 100 g and 2 400 g live weights of rabbits, the muscle:bone ratio of the carcass increases very rapidly until it reaches its maximum value, beyond which point it tends to decrease. Although not significantly different, the California breed had a higher muscle:bone ratio for the hind leg compared to the hybrid. However, this muscle:bone ratio for the hind leg showed an inverse relationship at 17-weeks-age. In this case the hybrid had a higher muscle:bone ratio (5.06) than the California breed (4.83). Significant differences between breeds were also observed at 9, 15 and 17 weeks for fore leg muscle:bone ratio, where the California breed had highest muscle:bone ratio compared to its counterpart (the hybrid).

4.4. Conclusions and recommendations

The present results show that regardless of the type of breed, the body weight increases with advancing age in the rabbit. Mature rabbits were characterised by a decrease in the proportion of organs and an improvement in muscular development, thus resulting in improved weights of retail cuts. However, feed conversion ratio improved with age for both breeds. Differences between breeds were primarily associated with head, feet proportions, full gastrointestinal tract and skin weight. In this regard head and feet constituted the highest proportion in the hybrid compared to the California breed and the California breed generally had lighter organ weights in relation to body weight when compared to hybrid. It can therefore be concluded that the California breed with its lighter organs and high values of meat yield, would be more suitable for meat production. However, this breed did not always show the superior feed conversion ratios, an important economic factor that also has to be taken into account when deciding on what breed to use. Research on the effect of age, breed and gender on these important economical traits when a balanced diet is formulated and fed is recommended.

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CHAPTER 5

Physical meat quality traits, proximate composition and mineral content of two rabbit breeds (California and hybrid)

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Abstract

To investigate the physical meat quality traits and proximate composition of rabbit meat, as a consequence of breed and age, 25 rabbits of each breed (California and hybrid = Dutch red x California) were housed in individual cages and 5 from each breed were slaughtered at 9, 11, 13, 15 and 17 weeks of age. Age significantly affected ($p < 0.01$) the physical meat quality traits of the rabbit. The younger rabbits reflected highest values of meat redness and similarly lightness decreased with age. The chill loss for the hybrid was generally higher than for the California breed. Increasing the age of animals significantly ($p < 0.01$) decreased the moisture content of the two breeds from 74 to 55% for California breed and 79 to 62% for the hybrids. The muscular fat content increased from 5 to 24% for the California breed and from 3 to 17% for the hybrid resulting in significance difference ($p < 0.05$) between breeds. No major differences were noted regarding the protein content of the two breeds except for rabbits at 9 weeks, where the hybrid showed a higher protein content than the California breed from 9 to 17 weeks, this protein content decreased from 20 to 17% for the California breed and from 21 to 18% for the hybrid. However, no significant differences were observed in ash content of the two breeds as affected by either age or breed. The effect of breed on the mineral elements that contributes the largest proportion to the total rabbit meat mineral profile was significant. In this regard California breed contained more phosphorus (175 mg/100 g) and magnesium (17.3 mg/100 g) compared to the hybrid (P=157 mg/100 g and Mg=14.2 mg/100 g). According to these results varying breed and slaughter age would be an effective approach to achieving maximum quality of rabbit meat.

Keywords: *Rabbit meat; slaughter age; physical meat quality traits; proximate composition of rabbit meat; mineral content of rabbit meat.*

5.1 Introduction

Consumers are becoming more and more interested in healthy products and usually prefer lean meat and carcasses. However, it should be remembered that fat is sometimes positively associated with acceptability. In this regard Sonandi, Masika and Van Averbeke (1996) found that Xhosas did not readily accept rabbit meat because they found it to be too lean. Hernandez, Pla and Blasco (1996) made it clear that fat contained in the meat, whether intramuscular or intermuscular, is a factor of meat quality.

Rabbit meat has many positive nutritional benefits that include low fat content and high quality protein (Lukefahr & Cheeke 1990, Fielding, 1991 & Sandford, 1986). Being rich in proteins and low in kilojoules, rabbit meat can be considered good for human consumption as health associations recommend that consumers control the number of kilojoules they consume (Stillings, 1994). Rabbit meat is also rich in vitamins and minerals. According to Arrington and Kelly (1976) 100 g of domesticated rabbit flesh can provide the following mineral elements: 20 mg calcium (Ca), 352 mg phosphorus (P), 1.3 mg iron (Fe), as opposed to its counterpart, namely (chicken) (Ca=12 mg, P=01 mg, Fe=2.6 mg, 100 g). The same amount of domesticated rabbit flesh can also provide the following essential vitamins: 0.08 mg thiamine, 0.06 mg riboflavin and 12.8 mg niacin. These vitamins are present in chicken in the following quantities (mg): thiamine (0.07), riboflavin (0.38) and niacin (5.6).

Although the composition of meat depends on age of slaughter, domestic rabbit meat of all ages is of high nutritive value for human consumption (Sandford, 1986, Szendro et al., 2002). Its high digestibility makes it suitable even for sick people and especially those with digestive problems and those with few teeth (Fielding, 1991, Sandford, 1986). In addition to age, breed also plays a major role in determining the quality of rabbit meat. In this regard a well-known phenomenon is that crossbreeding (mating of individuals from different breeds) results in hybrid vigour or heterosis in which the crossbred offspring are generally superior to the average of their purebred parents (Schoenian, 1998). Crossbreeding rabbits for meat purposes is very popular and often desirable, since crossbreeding improves the hybrid vigor in the fryers (Fielding, 1991).

Considering the physical meat qualities that influence the choice of a meat product, the first impression consumers have of any meat product is its colour. Fortunately the colour of meat can be controlled if factors that influence it are understood. Meat colour depends on the myoglobin concentration and one of the factors that significantly influences meat colour is age. The myoglobin concentration increases as an animal matures and with exercise. In the study conducted by Pla (2001) the strongest colour of rabbits reared at high temperatures was attributed to the fact that these animals grew slower and were thus slaughtered at an older age.

Little effort has been devoted to examining the effect of breed of South African rabbit on the nutritional value of the meat. The present study was therefore undertaken to collect data on physical quality

attributes, proximate composition, and mineral composition of two rabbit breeds (California and a commercial hybrid).

5.2 Materials and methods

Ethical permission was given by the research division of Stellenbosch University to conduct the study.

5.2.1 Animal and housing

A total of 50 rabbits from two breeds were used in the experiment. The two breeds were California and hybrid (Dutch red X California). The rabbits were purchased at the age of 8 weeks from two rabbit farms in the Western Cape. On arrival the rabbits were marked and weighed. The average initial weight recorded was 1 kg with a range of 0.93 kg – 1.4 kg for both breeds. Twenty five rabbits of each breed were randomly allocated to individual cages inside the rabbit house that was equipped with a fan to ensure coolness in hot days. During the fattening period of the animals, the average environmental temperatures ranged between 26-37°C. Each cage had a metallic feeder suspended at a reasonable height in front of the cage and an automatic nipple water supply system inside the cage.

5.2.2 Diet

During the entire feeding period, which lasted for 9 weeks, each animal had free access to a commercial pelleted diet from Bokomo feeds containing 160 g/kg protein, 150 g/kg fibre, 120 g/kg moisture, 25 g/kg fat, 8 g/kg calcium and 3.5 g/kg phosphorus. The intake of feed was recorded daily for each rabbit by weighing amounts offered and refused. The feeders were cleaned of any urinated food material as the need arose.

5.2.3 Slaughtering

The rabbits were slaughtered after fasting for 24 h, however during this time they had access to water. The slaughtering was performed at the Meat Science Laboratory in the Animal Science Department of the University where the live weight was recorded prior to slaughtering. This process took place over the entire experimental period at intervals of two weeks at 9, 11, 13, (commercial slaughter age), 15 and 17 (sexual maturity) weeks of age ($n = 5/$ breed/ period). Rabbits were slaughtered according to the national regulations applicable to commercial slaughtering. Thereafter the carcasses were prepared according to guidelines given by Blasco, Ouhayoun and Masoero (1993). This included removing the blood, skin, distal parts of the tail, fore and hind legs, gastrointestinal and urogenital tracts. The head, liver, lungs, heart and kidneys were also removed. To measure the chill loss the weight of the chilled carcasses was subtracted from the hot carcass weight.

5.2.4 Physical meat quality traits

The post-mortem pH and temperature were measured on the *M. biceps femoris* of hot carcass 45-60 minutes after slaughter (pH₄₅) and on the chilled carcass after 24 h (pH₂₄) post-mortem. Crison Instrument with a combined glass-electrode (penetrating 3 mm) was used following its calibration at pH₄ and pH₇ (Warris, 2000).

MLD was used for the determination of fresh meat colour. Three readings were taken per sample after blooming for 20 min. Colour was evaluated according to the method described by Honikel (1998) using a Colorgard System 2000 colorimeter (Pacific Scientific, Silver Spring, MD, USA) to determine L*, a* and b* values, with L* indicating lightness, a* the red-green range and b* the blue-yellow range. These values were also used to calculate the chroma value and hue angle according to the following equations, chroma = $\sqrt{a^{*2}+b^{*2}}$, and the hue angle (°) = $\tan^{-1}(b^*/a^*)$.

5.2.5 Proximate analysis

The meat from all rabbit carcasses including subcutaneous fat, was removed from the bones and cut into small samples to facilitate the mincing process. It was then finely minced to ensure a homogenous sample. The minced meat was vacuum-packed and kept at -20 °C until used for proximate chemical analysis. The percentage of moisture, protein and ash were determined according to the methods of the Association of Official Analytical Chemists (AOAC, 2002). The protein content was determined according to the Dumas combustion method using a Leco FP-528 method. To determine the moisture content, samples were dried in a 100 °C oven for 24 h. The lipid content was determined by extracting with a chloroform:methanol (2:1) mixture according to the method of Lee, Trevino and Chaiyawat (1996).

5.2.6 Mineral content

The elements phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), copper (Cu), zinc (Zn) and manganese (Mn) were determined from 5 rabbits of each breed using the 17-week-old rabbits. The mineral composition of the meat was determined after ashing of the defatted meat samples. The meat samples (1- 3 g) were air dried and ground to pass through a 0.5-1.0 mm sieve. Thereafter the samples were ashed overnight in a muffle furnace at 550 °C. A 6 M hydrochloric acid (HCl) solution was prepared by diluting 500 cm³ of a 36% (m:m) HCl solution to 1 dm³. After ashing, 5 cm³ of a 6 M HCl was added to dissolve the cooled sample. Thereafter the samples were dried in a waterbath. After cooling a 5 cm³ 6 M nitric acid (HNO₃) solution was added to the samples, then heated in a waterbath and removed after boiling point was reached. The solution was consequently filtered through filter paper into a 100 cm³ volumetric flask and diluted to volume with deionised water according to the method described by Giron (1973). Element concentrations were then measured on an ICP-Thermo Jarrel Ash, IRIS (AP).

5.2.7 Statistical analysis

A two factor factorial experiment was performed in a completely randomised design with 5 random replications. The factors were two breeds (California & hybrid). An experimental unit was a single carcass. The variables were recorded as interval data and subjected to an analysis of variance using SAS version 8.2 (SAS, 1999) statistical software. Shapiro-Wilk test was performed to test for non-normality (Shapiro & Wilk, 1965). Statistical significance differences were established at the 5% confidence level to compare treatment means (Ott, 1998).

5.3. Results and discussions

5.3.1 Physical meat quality

Meat colour measurements (L^* , a^* and b^* values) did not differ significantly between the two breeds, but was significantly influenced by age of slaughter. The results showed that the L^* values, a measure of lightness, decreased with an increase in age. The a^* value, a measure of surface redness was highest for the youngest rabbits (Table 1). The same results were noted by Dalle Zotte and Ouhayoun (1998) who explained that these results may be an indication of higher myoglobin content, as changes in myoglobin concentration during development are most likely the result of two contradictory effects, one being that myoglobin pigments decrease with a lowering of oxidative energy metabolism effect on colour, and the other being that myoglobin pigments accumulate with age, and thus yielding a more intense colour (Lawrie, 1998, Forrest et al., 1975). The a^* values obtained in this study were lower (0.86 to -1.26) than the results reported by Pla, Hernandez and Blasco (1996). High a^* values were also reported by Dal Bosco et al. (2002) from an experiment on the effect of housing system on the meat qualitative traits, where the following values were noted: 4.64 for those reared in a cage, 3.71 for the straw bedded and 4.06 for the wire netted pen.

The differences in colour could not be related to the variations found in pH. This was surprising as it is an established fact that the more acidic the muscle, the more tightly packed and the more reflective the structure of its myofibrillar proteins. In fact, the more mature the rabbit the more glycolytic its muscles, the lower its pH and the more highly reflective (Dalle Zotte et al., 1996).

Age showed no fixed trend as pertaining to pH_{45} and pH_{24} , (Table 1). There were however, differences between the two breeds, within age for this trait (pH). A low pH_{45} normally indicates antemortem stress (normally during the killing process) and a high pH_{24} indicates longer ante-mortem stress. Most of the pH_{24} values indicate that the rabbits were stressed prior to slaughter. This was probably a result of moving the rabbits from the experimental research facility to the meat laboratory. From the pH_{24} it would also seem as if the hybrid were either stressed more or more susceptible to stress. The former is most likely to be the factor as the hybrid were slaughtered last and may have been stressed whilst waiting in "lairage." The

“lairage” consisted of keeping the rabbits (grouped according to breed) in a transport cage that was kept in a quiet holding area.

Although temperature values varied as affected by age, the results of this study showed a direct relationship between temperature and pH; higher temperatures resulted in high pH values (Table 1), a trend observed for both breeds. The general rule stated by Ito, Kamisoyama and Osada (2000) is that under normal conditions, low pH values are not reached until the carcass has reached temperatures that are low enough to prevent excessive protein denaturation. However Dalle Zotte (2002) and Hulot and Ouhayoun (1998) stated that chilling duration has to be taken into account because if the carcasses of rabbits are exposed to short chilling, the rate at which the ultimate pH is reached will be lowered resulting in high pH values. In the present investigation the same chilling procedures were followed throughout the trial. It is important to note that high pH values in rabbit meat are not desired because they can affect enzyme activity and the rate of oxygenation in meat that consequently will affect colour stability of fresh meat.

Results of chill loss in this study are shown in Table 1, where significant differences ($p < 0.01$) depicted between certain age categories in decreasing order for both breeds. Significant chill loss differences were found between 9, 11 and 17 weeks for the California breed while the chill loss for the hybrid was only significantly higher at the ninth week. This decrease in percentage chill loss with an increase in rabbit age could be attributed to an increase in subcutaneous fat cover as the animals grew older (Table 2). It is well known that a good subcutaneous fat cover will minimise moisture loss in the chiller. Although not significantly different, the California breed tended to lose less moisture than the hybrid possibly due to the fact that the California breed had more subcutaneous fat (Table 2) which could have decreased the amount of dessication. The ability of meat to retain water is considered one of the most important meat quality parameters because it can influence the appearance, weight and juiciness of meat (Warris, 2000, Varnam and Sutherland, 1995).

Table 1

Effect of age on the carcass and meat quality traits of two rabbit breeds (California (CB) and hybrid (HB))

Traits		Age of slaughter (weeks)				
		9	11	13	15	17
pH ₄₅						
	CB	6.95±0.06 ^a	6.56±0.09 ^{bc}	6.57±0.10 ^{bc}	6.71±0.05 ^b	7.00±0.09 ^a
	HB	6.97±0.10 ^a	6.60±0.10 ^{bc}	6.70±0.11 ^b	6.49±0.15 ^c	6.62±0.10 ^{ab}
pH ₂₄						
	CB	5.91±0.04 ^a	5.95±0.06 ^a	5.85±0.15 ^a	5.90±0.12 ^a	5.99±0.12 ^a
	HB	6.25±0.13 ^a	6.03±0.03 ^{ab}	6.17±0.09 ^a	5.80±0.09 ^b	6.25±0.15 ^a
Temp ₄₅						
	CB	17.36±0.17 ^b	22.02±0.231 ^b	19.19±0.33 ^{ab}	21.20±0.47 ^{ab}	20.36±0.59 ^{ab}
	HB	17.28±0.47 ^{ab}	22.20±0.274 ^{ab}	20.54±0.33 ^{ab}	21.00±0.47 ^{ab}	21.52±0.78 ^a
Temp ₂₄						
	CB	12.76±0.35 ^a	8.34±0.20 ^b	7.09±0.99 ^c	5.16±0.67 ^d	5.38±0.20 ^d
	HB	10.38±0.46 ^a	9.08±0.12 ^b	9.24±0.55 ^b	5.40±0.58 ^d	6.24±0.47 ^c
Chill loss (%)						
	CB	9.80±0.65 ^a	4.13±0.25 ^b	3.41±0.10 ^{bc}	3.41±0.50 ^{bc}	3.13±0.09 ^c
	HB	11.16±0.44 ^a	4.36±0.11 ^b	4.36±0.50 ^b	2.75±0.23 ^{bc}	4.39±1.56 ^b
L*						
	CB	59.8±1.02 ^a	58.9±0.56 ^a	57.5±0.40 ^a	51.8±0.95 ^c	56.7±0.57 ^b
	HB	59.0±0.66 ^a	57.7±0.25 ^a	57.5±0.74 ^a	53.5±1.35 ^b	53.7±0.78 ^b
a*						
	CB	0.78±0.18 ^{a_B}	-0.20±0.12 ^b	-0.97±0.24 ^{bc_B}	-2.43±0.43 ^{d_B}	-1.45±0.16 ^{cd}
	HB	0.92±0.17 ^{a_A}	0.00±0.14 ^b	-0.17±0.59 ^{c_A}	-0.63±0.27 ^{cd_A}	-1.07±0.17 ^d
b*						
	CB	9.14±0.49 ^a	7.53±0.27 ^b	7.33±0.28 ^{b_A}	3.93±0.59 ^c	6.64±0.20 ^b
	HB	9.11±0.90 ^a	7.38±0.10 ^b	5.73±0.49 ^{bc_B}	3.77±0.99 ^d	6.42±0.22 ^b
Hue						
	CB	84.9±1.07 ^d	91.6±0.94 ^{cd}	97.4±1.90 ^{bc}	122.2±4.31 ^a	101.1±1.39 ^b
	HB	84.65±1.94 ^d	89.90±1.58 ^{cd}	92.8±05.19 ^c	109.0±3.37 ^a	99.41±1.40 ^b
Chroma						
	CB	9.18±0.49 ^a	7.54±0.27 ^b	7.44±0.29 ^b	4.67±0.65 ^c	6.82±0.20 ^b
	HB	9.17±0.92 ^a	7.39±0.10 ^b	5.84±0.52 ^c	3.86±0.99 ^d	6.51±0.23 ^{cb}

^{a-e} Means in the same row with different superscript letters are significantly different from one another (p<0.01)

^{A,B} Means in the same column between breeds for each trait, with different subscript letters are significantly different from each other (p<0.01)

± SD for 5 samples from each breed at different slaughtering periods.

5.3.2 Proximate composition

Age and breed influenced the moisture and fat content of rabbit meat significantly ($p < 0.05$) (Table 2), with the exceptions of meat obtained from 13-week-old rabbits which did not differ significantly ($p > 0.05$) regarding moisture content of two breeds. The moisture content decreased with increase in slaughter age, in relation with the age-related pattern of lipid content in the muscle. According to Szendro et al. (2002) and Gondret, Mourt and Bonneau (1998) fat is a late-developing tissue. These California breed meat had lower moisture content than the hybrid meat from 9 to 17 weeks of age. The lower moisture content was due to the significantly higher fat of the California breed at all ages of treatment (Table 2). This results are substantiated by findings of other researchers (Gondret et al., 1998, Warris, 2000 & Ouhayoun, 1998).

The protein content of rabbit meat differed significantly ($p < 0.05$) with slaughter age for certain age categories (Table 2). Generally, protein decreased with age in relation to the accumulation of fat. The average of decrease in protein content per slaughter age was higher in hybrid meat (20.7 to 16.09 g/100 g) between 9 and 17 weeks than in the California breed meat for the same period (19.8 to 17.0 g/100 g). However, a significant difference between breeds was noticed at 9 weeks. In this regard the hybrid muscles that were characteristically low in fat had the highest protein content compared to the California muscles. This relationship between protein content and fat content of rabbit muscles was reported by Fielding (1991), Ouhayoun (1998) and Pla et al. (1996).

Furthermore, it is important to note that an average value of 20% protein obtained in this study corresponded well to values reported by Arrington et al. (1976). While the fat content values of this study seemed to be higher than the values reported in the literature (3.29%), this factor could be attributed to the fact that these reports referred to the fat content from certain cuts of the rabbit carcass while this study included meat and fat from the whole carcass. The diet can also have possible effects on the total lipid of the carcass.

Table 2

Means for proximate chemical analysis of two rabbit breeds (California (CB) and hybrid (HB)) slaughtered at different ages (g/100 g)

		Age of slaughter (weeks)				
		9	11	13	15	17
Moisture	(CB)	74.15 [±] 0.18 ^a _B	68.57 [±] 0.87 ^b _B	68.44 [±] 0.77 ^b	65.69 [±] 0.72 ^c _B	55.83 [±] 0.80 ^d _B
	(HB)	75.76 [±] 0.49 ^a _A	71.22 [±] 0.60 ^b _A	68.77 [±] 0.30 ^c	68.90 [±] 0.61 ^c _A	62.37 [±] 1.35 ^d _A
Protein	(CB)	19.76 [±] 0.36 ^{ab} _B	20.65 [±] 0.69 ^a	18.35 [±] 0.49 ^b	17.65 [±] 0.35 ^c	17.03 [±] 0.42 ^c
	(HB)	20.65 [±] 0.27 ^a _A	20.68 [±] 0.29 ^a	18.47 [±] 0.13 ^b	18.01 [±] 0.47 ^c	16.90 [±] 0.25 ^b
Lipid	(CB)	5.56 [±] 0.26 ^e _A	9.01 [±] 0.27 ^d _A	12.06 [±] 0.50 ^c _A	14.95 [±] 0.54 ^b _A	24.98 [±] 0.60 ^a _A
	(HB)	3.12 [±] 0.58 ^e _B	7.18 [±] 0.33 ^d _B	11.07 [±] 0.25 ^c _B	12.65 [±] 0.68 ^b _B	17.89 [±] 1.45 ^a _B
Ash	(CB)	1.29 [±] 0.07 ^a	1.16 [±] 0.04 ^{ab}	1.22 [±] 0.12 ^a _B	1.09 [±] 0.02 ^c	1.09 [±] 0.01 ^c _B
	(HB)	1.29 [±] 0.07	1.18 [±] 0.01	1.34 [±] 0.02 _A	1.20 [±] 0.03	1.32 [±] 0.04 _A

^{a-e}Means in the same row with different superscript letters are significantly different from each other ($p < 0.05$)

_{A,B}Means in the same column, between breeds for each chemical constituent, with different subscript letters are significantly different from each other ($p < 0.01$)

[±] SD for 5 samples from each breed at different slaughtering periods.

5.3.3 Mineral content of two rabbit breeds

The mineral composition was determined for elements phosphorus, potassium, calcium, magnesium, sodium, iron, copper and zinc on the rabbits slaughtered at 17 weeks of age. Based on the results presented in Table 3, significant differences ($p < 0.05$) between the two breeds for four mineral elements (P, Mg, Cu and Zn) were found. Phosphorus seemed to be the most abundant mineral in rabbit meat, followed by potassium, magnesium, sodium and calcium in decreasing order. For phosphorus, the California breed had the highest average value of 175.13 mg/100 g whilst the hybrid had a value of 157.43 mg/100 g meat. A similar trend however, was noted in the composition of Mg and Zn content, with CB having the highest content and the HB having the lowest content of these minerals (Table 3). The meat from HB could contribute more Cu (1.11 mg/100 g) than the meat from CB (0.03 mg/100 g) in the human diet. These results are confirmed by other literature (Arrington et al. 1976, Dalle Zotte, 2002, Dierenfeld et al., 2002) stating that rabbit meat is low in Na, Ca and Fe but rich in K, P and Mg. However, it is important to note that the mineral analysis for this experiment was performed on the 17 week-rabbits, from meat samples which combined all the cuts of the rabbit carcass. In this regard the results of the present study

recorded lower values of Na (12.5 g/100 g) for both breeds compared to the results (33.4 mg/100 g at 13 weeks) noted by Parigi-Bini et al. (1992). These values indicate that rabbit meat with its lower Na content is more suitable for individuals with heart-related diseases.

Table 3

Means for mineral composition of rabbit meat as influenced by different breeds (California and hybrid)

Minerals	California	Hybrid	LSD
	(mg/100 g)		
Phosphorus	175.13 [±] 6.76 ^a	157.43 [±] 5.46 ^b	17.64
Potassium	140.34 [±] 4.56	123.08 [±] 8.12	20.12
Calcium	8.03 [±] 0.57	9.11 [±] 0.95	2.23
Magnesium	17.31 [±] 0.70 ^a	14.21 [±] 0.64 ^b	2.12
Sodium	12.53 [±] 0.34	12.58 [±] 0.55	1.17
Iron	1.03 [±] 0.06	0.86 [±] 0.06	0.18
Copper	0.03 [±] 0.01 ^b	0.11 [±] 0.03 ^a	0.06
Zinc	1.35 [±] 0.05 ^a	1.13 [±] 0.06 ^b	0.16
Manganese	0.03 [±] 0.01	0.03 [±] 0.01	0.01

^{a-b} Means in the same row with different superscript letters are significantly different ($P \leq 0.05$)

[±]SD for 5 samples from each breed at 17 weeks age.

5.4 Conclusions and recommendations

The aim of this study was to investigate the effect of age and breed on the physical rabbit meat quality traits (colour, pH and chill loss), the proximate composition and the effect of breed on the mineral content of the carcass.

The results presented here indicate differences in the pH₂₄ of the two breeds. These differences show that the hybrid was more stressed than the California breed rabbits probably because the former were slaughtered last and thus suffered anxiety whilst waiting in "lairage". The chill loss was significantly affected by age which was related to the subcutaneous fat cover. However, although not significantly different the California breed that was characteristically fatter tended to lose less moisture than the hybrid.

The age-related pattern of decrease in moisture content was consistent with the increase in total fat content of rabbit meat, similarly the protein content consistently decreased. Fat is associated with

improved eating quality of rabbit meat, which is low in fat, and generally considered to be insufficiently tasty and juicy. With this in mind it can be concluded that in order to improve the eating quality of rabbit meat the intramuscular fat content should be increased. This can be achieved by delaying the age of slaughter for rabbits. However, it should not be forgotten that producing meat with high fat content becomes a disadvantage due to a number of expenses involved such as prolonged feeding and a decrease in food conversion ratio.

The present study indicated that type of breed influenced the carcass composition of P, Mg, Cu and Zn, and in this regard California consisted of higher concentrations of these mineral elements than the hybrid., The only exception was with copper where the hybrid had the higher content. The results of this study showed that rabbit meat contained lower levels of sodium and could be recommended for people that wish to decrease the Na content in their diets. Although, rabbit meat showed overall lower total carcass fat and high protein content, little is known about the fatty acids, cholesterol and amino acids content of California breed vs hybrid. The composition of these compounds in these two rabbit breeds is in need of further research.

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CHAPTER 6

Effect of breed on fatty acid composition, cholesterol content and amino acid composition of rabbit meat

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Abstract

The effect of breed on fatty acid composition, cholesterol content and amino acid composition of rabbit meat was determined using 17-week-old rabbits from two different breeds (California and hybrid = Dutch red X California breed). Results indicated that rabbit meat is characterised by considerably low saturated fatty acids (SFA) and approximately 66% of unsaturated fatty acids (UFA) which are basically made up of 33% monounsaturated fatty acids (MUFA) and 33% polyunsaturated fatty acids (PUFA) for the hybrid, while 37% MUFA and 30% PUFA formed the UFA profile of the California breed. The main constituents of the identified fatty acids in both breeds were palmitic (C16:0), stearic (C18:0), oleic (C18:1), palmitoleic (C16:1), linoleic (C18:2) and α -linolenic (C18:3n-3). The other fatty acid components constituted considerably low percentages ranging from 0.024% (C18:3n-6) to 0.6% (C20:4n-6). Among the fatty acids analysed, the significant difference ($p < 0.05$) between breeds was evident in the concentration of C16:0, (palmitoleic), (C16:1n-7) and C18:1 in quantitative data resulting in the highest total fatty acid concentration in the California breed (169.2 mg/100 g) vs the hybrid (133.5 mg/100 g). Rabbit meat can provide a balanced fatty acid intake to consumers with a 0.9 PUFA:SFA ratio obtained in this study. Differences between the breeds pertaining to desirable fatty acids content in mg/100 g were also noted. A comparison of breed on the level of cholesterol showed no significant difference between breeds with California having 58 mg/100 g and the hybrid 57mg/100 g meat. The total amount of amino acids in both breeds varied from 111.9 g/100 g and 106.4 g/100 g proteins for California breed and hybrid respectively with no significant difference between breeds ($p > 0.05$). Glutamic acid, aspartic acid, alanine, lysine and leucine were identified in higher amounts compared to other amino acids. The results revealed that rabbit meat contains almost all essential amino acids except tryptophan. Due to its high content of PUFA, a desirable PUFA:SFA, low cholesterol and satisfactory constituent of essential amino acids, rabbit meat could contribute to the healthy diet for human beings.

keywords: rabbit meat; fatty acids; cholesterol; amino acids

6.1 Introduction

White meat consumption has become important in recent years due to the overall consumer concern about the high fat content of traditional red meat (Higgs, 2000, Stillings, 1994). Food with a high percentage dietary fat is associated with an increased risk of heart disease, cancer, stroke, diabetes and gastrointestinal diseases (Jimenez-Colmenero, et al., 2001, Sloan, 2002 & Stillings, 1994). According to Sloan (1999) consumers readily purchase food that is perceived as a tool for disease prevention and for self treatment of specific health conditions.

By introducing rabbit meat to the human diet, the consumer will be able to consume a higher percentage of polyunsaturated fatty acids (PUFA). According to Fielding (1991), rabbit meat is characterised by a low fat content that is mainly unsaturated. Polyunsaturated fatty acids are perceived to be healthier than saturated fat. The cholesterol content of rabbit meat is also low and this is an important characteristic that makes rabbit meat more attractive to the health-conscious consumers (Piles, Blasco & Pla, 2000, Warriss, 2000).

The effect of breed is an important factor in the quality of rabbit meat, for the simple reason that genetic factors can affect the characteristic flavour profile of meat, and this can result in a different taste, a phenomenon attributed to the variation in the fatty acid and amino acids composition in different breeds (Hui-Chun WU & Chyuan-Yuan Shiau, 2002). This variation may be in levels of concentration, relative proportion or in the type of fatty acid or amino acid. In this regard very lean breeds could have relatively high proportions of PUFA compared with fatter breeds in which the phospholipids effect is diluted by higher levels of neutral storage lipid or marbling fat (Enser et al., 1996, Fisher et al., 2000). It is therefore important to consider the polyunsaturated fatty acid:saturated fatty acid ratio (PUFA:SFA) that is recommended to be > 0.7 and the n6:n3 ratio in fatty acids of rabbit meat, which according to the British Department of Health is supposed to be < 5 for the total diet (Enser, 2001, Raes, De Smet & Demeyer, 2003).

No report could be sourced in the literature as pertaining to the influence of rabbit breeds in South Africa on their meat composition. The objective of this study was therefore to investigate the effect of breed on the fatty acids composition, cholesterol content and amino acids composition of rabbit meat.

6.2 Materials and methods

6.2.1 Animals and housing

The rabbit meat used in this investigation was obtained from animals raised at the experimental farm of Stellenbosch University in South Africa. The differences in two breeds were determined in terms of fatty acids composition, cholesterol content and amino acids composition.

The two breeds were California (CB) and hybrid (HB) (a cross between Dutch Red x California). The rabbits were purchased at the age of 8 weeks from two rabbit farms in the Western Cape, South Africa. On arrival the rabbits were marked and weighed. The average initial weight recorded was 1 kg with a range of 0.93 kg – 1.4 kg for both breeds. Rabbits of each breed were randomly allocated to individual cages inside the rabbit house that was equipped with a fan to ensure coolness in hot days. During the fattening period of the animals, the average environmental temperatures ranged between 26-37°C. Each cage had a metallic feeder suspended at a reasonable height in front of the cage and an automatic nipple water supply system inside the cage.

6.2.2 Diet

During the entire fattening period which lasted for 9 weeks, each animal had free access to a commercial pelleted diet from Bokomo feeds containing 160 g/kg protein, 150 g/kg fibre, 120 g/kg moisture, 25 g/kg fat, 8 g/kg calcium and 3.5 g/kg phosphorus. The intake of feed was recorded daily for each rabbit by weighing amounts offered and refused. The feeders were cleaned of any urinated food material as the need arose.

6.2.3 Slaughtering

The rabbits were slaughtered after fasting for 24 h. However during this time they had access to water. The slaughtering was performed at the Meat Science Laboratory in the Animal Science Department of the University. Rabbits were slaughtered according to the national regulations applied to commercial slaughtering. Thereafter the carcasses were prepared according to procedures specified by Blasco et al. (1993). This included removing the blood, skin, distal parts of the tail, fore and hind legs and gastrointestinal and urogenital tracts. The head, liver, lungs, heart and kidneys were also removed. In the present investigation 5 rabbits from each breed were used, these rabbits were all 17 weeks old and had a mean live weight of 3.19 ± 0.13 and 3.30 ± 0.14 kg for California and hybrid respectively. This yielded a slaughter weight of 3.06 ± 3.86 and 3.13 ± 0.56 kg for California breed and hybrid.

6.2.4 Sample preparation

The carcasses were cooled overnight at 4°C. Thereafter they were deboned and the meat cut into small samples to facilitate the mincing process. The minced meat was vacuum-packed and kept at -20°C until used for chemical analysis.

6.2.5 Chemical composition

6.2.5.1 Fatty acid analysis

The fatty acid composition was determined by the method described by Tichelaar, Smuts, Van Stuijvenberg, Faber and Benade (1998). After thawing the meat a 2 g sample was extracted with chloroform/methanol (CM 2:1; v/v) according to a modified method of Folch, Lees and Sloane-Stanley

(1957). All the extraction solvents contained 0.01% butylated hydroxytoluene (BHT) as an antioxidant. A polytron mixer (Kinematica, type PT 10-35, Switzerland) was used to homogenize the sample within the extraction solvent. Heptadecanoic acid (C17:0) was used as an internal standard to quantify the individual fatty acids. A sub-sample of the extracted lipids was transmethylated for 2h at 70°C using methanol/sulphuric acid (19:1; v/v) as transmethylating agent. After cooling, the resulting fatty acid methyl esters (FAME) were extracted with water and hexane. The top hexane phase was transferred to a spotting tube and dried under nitrogen.

The FAME were purified by TLC (silica gel 60 plates) and analysed by GLC (Varian Model 3300 equipped with flame ionisation detection) using 60 m BPX70 capillary columns of 0.25 mm internal diameter (SGE, Australia). Gas flow rates were: hydrogen, 25 ml/min; and hydrogen carrier gas 2-4 ml/min. Temperature programming was linear at 3°C/min, with an initial temperature of 150°C, a final temperature of 220°C, an injector temperature of 240°C and a detector temperature of 250°C. The FAME were identified by comparison of the retention times to those of a standard FAME mixture (Nu-Chek-Prep Inc., Elysian, Minnesota).

6.2.5.2 Cholesterol analysis

From the same lipid extraction used for fatty acid determination, a sub-sample was used for the determination of cholesterol content. After drying the sub-sample under nitrogen, Stigmasterol (3-B-hydroxy-24-ethyl-5.22-cholestadiene) (Sigma Chemical Co., St Louis, MO, USA) was added as internal standard and 6% ethanolic KOH used to saponify the extraction for 2 h at 70°C in a heating block. After cooling, distilled water and hexane were added and the resultant extraction was analysed by GLC (Varian Model 3700, equipped with flame ionization detection). A 1.2 m glass column of 2 mm internal diameter packed with 3% SP2401 on 100/120 mesh Supelcoport (Supelco Inc., Bellefonte, PA, USA) was used. Gas flow rates were: Hydrogen, 20 ml/min; air, 200 ml/min and nitrogen (carrier gas), 25 ml/min. The injector temperature; column temperature and detector temperature was respectively 280°C, 255°C and 290°C.

6.2.5.3 Amino acids analysis

The amino acid composition was determined using a modification of the method of Bidlingmeyer, Cohen and Tarvin (1984) on a defatted sample of, dried meat using a Waters high performance liquid chromatography system (1525 HPLC with a binary gradient delivery, 717 auto-sampler and injector, 1500 column heater, 2487 dual wavelength UV detector and a Breeze data workstation (Waters, Millford, MA, USA). The sample was defatted by solvent extraction according to the method of Lee, Trevino and Chaiyawat (1996) and hydrolysed with 6 N HCl in a vacuum-sealed tube for 24 h at 110°C. Thereafter the samples were centrifuged (15 krpm for 5 min) and dried under vacuum for 1.5 to 2 h. The pH was adjusted by adding 20 µl solution of 2:2:1 ethanol: water: triethylamine and the samples were dried for a further 1.5 to 2 h. The resulting sample was derivatised by adding 20 µl solution ethanol in the ratio of 7:1:1:1 ethanol:water:triethylamine:phenylisothiocyanate derivatizing solution which was allowed to react

at room temperature for 10 min prior to drying under vacuum (minimum of 3 h). The sample was resuspended in 200 μ l of Picotag sample diluent (Waters, Millford, MA, USA) and an 8 μ l sub-sample was then injected for separation by HPLC under gradient conditions, where buffer A was sodium acetate buffer (pH 6.4) containing 5000 ppm EDTA, 1:2000 triethylamine and 6% acetonitrile and buffer B was 60% acetonitrile with 5000 ppm EDTA. The data was analysed using Breeze software (Waters, USA).

6.2.6 Statistical analysis

A two factor factorial experiment was performed in a completely randomised design. The factors were two breeds (California and hybrid). An experimental unit was a single carcass. The variables were recorded and subjected to an analysis of variance using SAS version 8.2 (SAS, 1999) statistical software. Shapiro-Wilk test was performed to test for non-normality (Shapiro & Wilk, 1965). Statistical significance differences were established at the 5% confidence level to compare treatment means (Ott, 1998).

6.3. Results and discussions

6.3.1 Fatty acid composition

In Table 1, the fatty acid composition of the rabbit muscles are presented quantitatively (mg/100 g muscles) and qualitatively (% of total fatty acids identified). According to Enser, Hallett, Fursey, Wood and Harrington (1998) the percentage representation of fatty acids can be misleading especially if the treatments only differ in total fatty acid content. Although the mean percentage of different fatty acids can be misleading it still gives a fair indication of the distribution between them. The composition of fatty acids in mg per 100 g muscle is certainly useful, especially when calculating the nutritional value of a food portion.

According to these results, the fatty acids detected in the highest concentrations were oleic (C18:1, 31.5 and 30.2%), linoleic (C18:2 n-6, 26.8 and 29.1%) and palmitic (C16:0, 24.8 and 24.2%) for the California breed and the hybrid respectively. These results are in agreement with those of Ramirez, Diaz, Pla, Gil, Blasco, and Oliver (2002) who found that linoleic, palmitic and oleic fatty acids constituted the higher proportions of fatty acids in rabbit meat. The lower value found for stearic was expected, as findings by Jithendran (2002) indicated that rabbit fat contains less stearic and oleic acids than other species and higher proportions of the essential polyunsaturated linoleic acid.

The total fatty acid composition of the rabbit meat was highest (169.24 mg/100 g) for the California breed and least (133.49 mg/100 g) for the hybrid. This was due to the most obvious differences in fatty acid composition regarding palmitic (C16:0), oleic (C18:1) and (C16:1 n-7) that were significantly higher in the California breed than in the hybrid (Table 1). These differences also resulted in a much higher total saturated fatty acid (SFA) content (55.4 vs 44.2 mg/100 g) and total monounsaturated fatty acid (MUFA) content (62.32 vs 45.60 mg/100 g) contents in the California breed compared to the hybrid. The higher values in the California breed can be explained by the higher percentages of fat noted in this breed (5.6-

24.9%) compared to the hybrid (3.12-17.9%) at an age of 9-17 weeks (Nkhabutlane, Hoffman & Vosloo, 2004). This confirms the known fact that fatness affects the fatty acid composition of total lipids because the triacylglycerols, which increase with fatness, are less unsaturated than the more constant phospholipids in muscle membranes (Enser et al., 1998). The study also showed that the unsaturated fatty acids (UFA) constitute the highest proportion of total fatty acids in rabbit meat, contributing to approximately 66% of the total fatty acid profile. These results are in agreement with Gittens (2000) that unsaturated fatty acid composition of rabbit meat is approximately 63% of the total fatty acids. PUFA constituted one third of the total fatty acids of rabbit meat with the California breed showing 30% and the hybrid showing 33%.

Conjugated linoleic acid (CLA) (C18:2 n-6) is currently of high interest (Enser, 2001). It is associated with quite a range of potential health benefits which include functioning as an anti-carcinogen, aiding in the utilisation of energy for muscle production instead of adipose tissue production, and in the protection against atherosclerosis and the modification of the immune response. This fatty acid was found in considerable amounts in both breeds. Results of this study are comparable to the values identified in two groups of rabbits selected for growth rate (32.8 and 31.5%) by Ramires et al. (2002).

The desirable fatty acids are obtained from the sum of all fatty acids that have a lowering effect (UFA) and neutral effect (C18:0) on cholesterol. The significant difference ($p < 0.05$) between breeds in desirable fatty acids (DFA) content was noted with the California breed having more (127.12 mg/100 g) thereof than the hybrid (100.91 mg/100 g). Nevertheless, the meat from both breeds contained 75% DFA (Table 1). With reference to the fact that palmitic acid increases blood cholesterol while stearic has a neutral effect on cholesterol and that there is an evidence for monounsaturated (n-9) fatty acids to lower cholesterol levels, it was therefore important to consider their concentrations in order to determine the desirable ratio for human nutrition (Lawrie, 1998). In this regard no significant differences between the two breeds were observed in the (C18:0+C18:1):C16 ratio.

It is well known that the increased intake of SFA contribute to higher risks of heart disease by raising the low-density lipoprotein in the cholesterol plasma, while linoleic acid and α -linolenic acid lower it, thereby decreasing the risk of heart disease. On the other hand, stearic acid has no effect on the plasma cholesterol concentrations, although it may contribute to the final stages of coronary heart disease that produce the heart attack (Enser, 2001). It is therefore important to scale down SFA intake and maintain the balance by substituting it with PUFA in order to maintain good human nutrition. This can be achieved by calculating the PUFA:SFA (P:S) ratio that will enable the assessment of the quality of fat in terms of the dietary recommended value of ≥ 0.7 (Raes et al., 2003). Although there was no significant difference between the P:S ratio of the two rabbit breeds, the values obtained were higher (+0.9) than the 0.7. recommended. This is an indication that rabbit meat contains a P:S ratio that could be considered very desirable, considering the fact that some meats naturally have a P:S ratio of about 0.1 (Wood et al., 2003).

In addition to the P:S ratio, it was also important to consider the quality of the PUFA in the rabbit meat from the two breeds because diets with high n3-PUFA tend to decrease blood clotting, protect against diabetes, cancer and inflammatory processes in the body, while n6-PUFA generally increases these processes (Warriss, 2000). In this study the California breed had a ratio of 11.8 and the hybrid a ratio of 12.7. These results are higher than the results reported by Ramirez et al. (2000) (8.73 and 8.38 respectively) but they are in agreement with Dalle Zotte (2002) who noted 11.6 from rabbit leg. The Department of Health and Social Security in the United States recommends a ratio of 4 for n-6:n-3 (Enser, 2001, Wood et al., 2003) while the British Nutrition Foundation suggests the increased consumption of n3 and reducing the n-6:n-3 ratio to $\leq 6:1$ (Dal Bosco et al., 2003). Rabbit meat with such a high ratio will be less desirable.

Table 1

Fatty acid content, composition and ratios of California and hybrid rabbit meat

Fatty acid	mg/100 g muscle			% of total fat identified		
	CB	HB	LSD	CB	HB	LSD
Total FA	169.24 ^a	133.49 ^b	33.45	100.0	100.0	0
C16:0	42.02 ^a	32.34 ^b	8.51	24.84	24.21	1.92
C18:0	13.18	11.66	2.86	7.80	8.78	1.13
C20:0	0.20	0.23	0.03	0.12 ^b	0.18 ^a	0.03
C18:1	53.31 ^a	40.63 ^b	11.87	31.50	30.20	1.58
C16:1(n-7)	8.37 ^a	4.49 ^b	3.14	4.92 ^a	3.18 ^b	1.54
C20:1(n-9)	0.64	0.48	0.18	0.39	0.36	0.10
C18:2(n-6)	45.36	38.32	7.71	26.80	29.05	2.48
C18:3(n-6)	0.04	0.05	0.15	0.02	0.03	0.09
C18:3(n-3)	3.47	2.82	0.95	2.04	2.11	0.29
C20:2(n-6)	0.54	0.44	0.17	0.32	0.33	0.10
C20:3(n-9)	0.28	0.26	0.17	0.17	0.20	0.12
C20:4(n-6)	0.93	0.93	0.12	0.55	0.74	0.23
C22:4(n-6)	0.37	0.46	0.15	0.22 ^b	0.36 ^a	0.12
C22:5(n-3)	0.26	0.27	0.15	0.15	0.21	0.10
C22:6(n:3)	0.26	0.10	0.19	0.16	0.08	0.14
SFA	55.4 ^a	44.23 ^b	10.85	32.75	33.16	1.44
MUFA	62.32 ^a	45.60 ^b	14.69	36.80 ^a	33.74 ^b	2.82
PUFA	51.52	43.66	8.78	30.44	33.10	2.84
DFA	127.02 ^a	100.91 ^b	25.39	75.04	75.62	1.91
PUFA:SFA	0.93	0.99	0.11	0.93	0.99	0.11
n6:n3	11.84	12.6	1.82	11.86	12.75	1.82
(C18:0+ 18:1):C16:0	1.58	1.62	0.17	1.58	1.61	0.17

Means for 5 samples from each breed

^{a-b}Means in the same row, within grouping, with different superscript letters are significantly different ($p \leq 0.05$)

SFA = Saturated fatty acids

MUFA = Monounsaturated fatty acids

PUFA = Polyunsaturated fatty acids

PUFA:SFA = Ratio of polyunsaturated fatty acids to saturated fatty acids

DFA= Desirable fatty acids (total unsaturated fatty acids+ stearic acid)

6.3.2 Cholesterol content

The result of this study showed no significant difference ($p>0.05$), $LSD= 11.92$ mg/100g muscle between cholesterol levels of the California breed (58.1 mg/100 g muscle) and hybrid (57.4 mg/100 g muscle). According to Lawrie (1991) genetic factors and feeding practices, can affect total fat deposition in animals. However, within species, genetics have little or no effect on cholesterol concentration. Parigi-Bini et al. (1992) reported a cholesterol level of 44.8 mg/100 g from rabbits slaughtered at an age of 13 weeks. The higher values obtained in this study may be attributed to the fact that the cholesterol level was investigated in 17 week-old rabbits that were characteristically fatter compared to rabbits of younger age (Nkhabutlane et al., 2003). According to Lawrie (1991) fatter animal muscles consequently lead to increased levels of cholesterol. Apart from fat, cholesterol levels can also be affected by contamination of the bone marrow during deboning (Al-Najdawi & Abdullah, 2002). Cholesterol levels reported by Bragagnolo (2001) for other meats ranged from 51-56 mg/100 g for beef cuts, 40-54 mg/100 g for pork and 58 mg/100 g for chicken meat. It is also important to note that according to the European Department of Health (1994) as cited by Enser (2001) the recommended intake of cholesterol should be maintained below 245 mg/day. Thus rabbit meat has a considerably low cholesterol level in view of this recommendation.

6.3.3 Amino acid content and composition

Table 2 presents the amino acid composition expressed as g/100 g protein and g/100 g sample (muscle as is) for the two breeds (California and hybrid). The amino acid profile of the two breeds did not differ significantly ($p>0.05$). These results confirm the findings that the amino acid content of meat protein is quite constant, regardless of the species or the type of cut from which the meat is obtained (Dawood, 1995). In contrast, Lawrie (1991) noted significant differences in amino acid composition as a result of the influence of muscle locations, breed or animal age. Glutamic acid, aspartic acid, alanine, lysine and leucine were the major amino acids identified in rabbit meat in decreasing order, ranging from 13.8-8.7 g/100 g proteins. The relative proportion of the essential amino acids to the total amino acid profile in California and hybrid were 36.5% and 40.4% respectively. In agreement with these results Kamal, Youssef, Abou-El-Hawa, El-Rify and Khalifa (1992) reported the highest concentration of leucine-isoleucine mixture (about 12.6 g/100 g protein) in the essential amino acid profile of rabbit meat. However, they also identified minute traces of tryptophane in the California breed which were not identified in this study. According to Warris (2000), a lack of essential amino acids in the body could hinder syntheses and lower the body's required level of essential proteins, which in turn can lead to problems, related to indigestion, depression and stunted growth. Thus, the results of this study shows that consumption of rabbit meat will help in the prevention of these problems.

Table 2

Amino acid composition of two different rabbit breeds (California and Hybrid)

Amino acids	g/100 g sample			g/100 g protein		
	CB	HB	LSD	CB	HB	LSD
Aspartic acid (asp)	1.98 \pm 0.19	1.95 \pm 0.28	0.35	11.63 \pm 0.73	10.71 \pm 1.43	1.65
Glutamic acid (glu)	2.35 \pm 0.24	2.40 \pm 0.20	0.33	13.80 \pm 1.03	13.19 \pm 0.98	1.46
Serine (ser)	1.31 \pm 0.13	1.28 \pm 0.15	0.20	7.73 \pm 0.48	7.03 \pm 0.65	0.84
Glycine (gly)	1.26 \pm 0.13	1.44 \pm 0.20	0.25	7.42 \pm 0.56	7.92 \pm 1.07	1.24
Histidine (his)	0.56 \pm 0.07	0.56 \pm 0.11	0.13	3.27 \pm 0.36	3.05 \pm 0.53	0.66
Arginine (arg)	0.92 \pm 0.10	0.92 \pm 0.11	0.15	5.39 \pm 0.36	5.06 \pm 0.53	0.66
Threonine (thr)	1.17 \pm 0.11	1.19 \pm 0.13	0.18	6.90 \pm 0.38	6.53 \pm 0.68	0.80
Alanine (ala)	1.82 \pm 0.20	1.90 \pm 0.20	0.29	10.67 \pm 0.86	10.47 \pm 1.00	1.36
Proline (pro)	0.88 \pm 0.08	0.98 \pm 0.14	0.17	5.15 \pm 0.33	5.38 \pm 0.71	0.80
Tyrosine (tyr)	0.50 \pm 0.05	0.51 \pm 0.05	0.08	2.96 \pm 0.22	2.79 \pm 0.22	0.32
Valine (val)	0.95 \pm 0.10	0.96 \pm 0.10	0.15	5.58 \pm 0.43	5.26 \pm 0.43	0.62
Methionine (met)	0.53 \pm 0.05	0.62 \pm 0.18	0.20	3.09 \pm 0.21	3.40 \pm 0.98	1.03
Cystine (cys)	0.13 \pm 0.03	0.11 \pm 0.01	0.03	0.75 \pm 0.17	0.62 \pm 0.06	0.18
Isoleucine (ile)	0.75 \pm 0.08	0.73 \pm 0.08	0.12	4.41 \pm 0.34	4.04 \pm 0.33	0.49
Leucine (leu)	1.60 \pm 0.16	1.57 \pm 0.18	0.25	9.38 \pm 0.71	8.66 \pm 0.76	1.08
Phenylalanine (phe)	0.55 \pm 0.06	0.54 \pm 0.07	0.10	3.20 \pm 0.24	2.96 \pm 0.30	0.40
Lysine (lys)	1.80 \pm 0.23	1.66 \pm 0.25	0.36	10.55 \pm 0.75	9.10 \pm 1.20	1.46
Total	19.05 \pm 1.96	19.34 \pm 1.87	2.10	111.93 \pm 7.70	106.45 \pm 8.09	3.23

 \pm SD for 5 samples from each breedNo significant difference ($p>0.05$)

6.4 Conclusions and recommendations

The effect of breed was investigated on the fatty acids composition, cholesterol content and amino acids composition of rabbit meat using 17-week-old South African rabbits (California breed and hybrid = Dutch Red X California). The results of this investigation have demonstrated that breed has a significant effect on the composition of fatty acids in rabbit meat. A significant difference ($p<0.05$) was detected in the total composition of fatty acids, where the California breed had a higher total fatty acid profile than the hybrid.

These differences were a result of the higher values obtained from SFA, MUFA and PUFA for California breed vs hybrid. The P:S ratios of both breeds exceeded the recommended level of >0.4 thus rabbit meat with its high P:S ratio (+0.9) could be recommended to reduce plasma cholesterol. On the other hand the n6:n3 ratios of the two breeds showed higher values (11.8) that are not so desirable for human nutrition. Thus the industries producing rabbit meat are faced with the challenge to manipulate the diet of rabbits in order to achieve rabbit meat with a more favourable n-6:n-3 ratio. The results generally showed that fatty acids composition is directly related to the muscular fat content of rabbit meat. In this regard the fatter breed (California) had more fatty acids than the leaner breed (hybrid). However, the cholesterol content did not differ significantly between the two breeds. According to the results of this study essential amino acids contributed 36.5% and 40.4% for California and hybrid to the total amino acid profile of rabbit meat. Breed generally had no effect ($p>0.05$) on the amino acid composition of rabbit meat. Considering the benefits of rabbit meat in terms of high UFA and low cholesterol obtained in this study, research is needed about the attitude of South African consumers towards rabbit meat, in particular to find out if they are aware of the potential health benefits associated with rabbit meat and most importantly their overall perception and understanding about rabbit meat.

6.5 References

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CHAPTER 7

THE PERCEPTIONS OF DIFFERENT ETHNIC GROUPS ON RABBIT MEAT CONSUMPTION

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Opsomming

Die produksie van konynvleis kan 'n lonende mikro-besigheid wees, en het die potensiaal om voedselsekureit te kan verseker. Dit verskaf 'n gesonde alternatief vir die verbruiker, weens die gunstige vetsuur-profiel en hoë proteïeninhoud. Ongelukkig is data oor die veranderlikes wat die potensiele verbruik van konynvleis in Suid-Afrika beïnvloed, nie beskikbaar nie. Die persepsie en kulturele opvattinge wat geassosieër word met die eet van konynvleis is ondersoek vir drie etniese groepe, naamlik swart (n=101), wit (n=102) en bruin respondente (n=101) in die Wes-Kaap waartydens gebruik gemaak is van 'n gestruktureerde vraelys wat vooraf getoets en verryin is. Die eienskappe wat betrekking gehad het op die demografiese profiel van die respondente, het hul houding teenoor die konynvleis betekenisvol beïnvloed ($p < 0.05$). Swart en bruin respondente het konyne met jag en met wilde diere geassosieer, terwyl die wit respondente konyne as hasies beskou het. Die resultate suggereer voedsal assosiasies met hoender en 'n smaaklike bredie. Die respondente (47%, n=142) het voorheen al konynvleis geëet (tuis, by 'n restaurant of na 'n jag). Vorige ervarings vand ie eet van konynvleis blyk 'n positiewe invloed te hê op die begeerte om dit weer te eet. Meer as die helfte van die respondente (52%, n=158) het nog nooit konynvleis geëet nie. Desondanks dié feit, het 46% (n=73) aangedui dat hulle gewillig sou wees om dit op die proef te stel, indien dit beskikbaar sou wees. Daar is betekenisvolle verskille in die verskillende etniese groepe se gelowe en bygelowe, en verdere ondersoek sal nodig wees voordat daar uitsprake met betrekking tot die swart populاسie in Suid-Afrika gemaak kan word. Die respondente se gebrek aan kennis van konynvleis en die skaarsheid van dié vleissoort dra grootliks by tot die beperkte gewildheid wat dit onder die respondente in dié studie geniet.

Abstract

The production of rabbit meat can be a profitable micro-enterprise with the potential to ensure food security. It is an option for the health-conscious consumers with its good fatty acid profile and high protein content. However, data on the variables affecting the potential consumption of rabbit meat in South Africa is not available. Perceptions and cultural beliefs associated with consumption of rabbit meat, as influenced by three ethnic groups, namely black (n=101), white (n=102) and coloured respondents (n=101) were investigated in a Western Cape study through a survey employing a structured questionnaire, which had been tested and refined before hand. The properties related to the demographic profile of the respondents significantly influenced ($p < 0.05$) their attitude to the rabbit meat. Black and coloured respondents associated rabbits with hunting and wild animals, white respondents tended to regard them as bunnies. The results suggested food associations with chicken and with a tasty stew. Some of the respondents (47%, n=142) had eaten rabbit meat before (at home, restaurant and from hunting). Having consumed rabbit meat before seemed to contribute positively to the desire to eat it again. More than half the respondents (52%, n=158) had never eaten rabbit before. However, 46% (n=73) were willing to try it, if available. Ethnic groups differed significantly regarding beliefs and superstitions and require further investigation to generalise in terms of the black South African population. Lack of knowledge about rabbit meat and its scarcity contribute a great deal to its limited popularity among the respondents in this study.

Keywords: Food choice; rabbit meat; perceptions regarding rabbit meat; Ethnic influences on food choice

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7.1 Introduction

A better understanding of consumer attitudes towards a product is very important because the success thereof is determined by its conformance to the needs of consumers (Dalle Zotte, 2002:14, Verbeke, 2002, Warriss, 2001:5). Consumer preference for rabbit meat is always ranked at a lower level when compared to other meats (Hoffmann, Kobling, Stier & Gall, 1992). The negative attitude towards game meat, as mentioned in Bezuidenhout's report (2001:31), namely that ignorance of the benefits associated with game meat may be the contributing factor towards limiting its consumption, also apply to rabbit meat. These results indicated that most consumers showed great appreciation of game meat after being informed of its nutritional value when compared to other meats. Nyete, cited by Gittens (2000:50), stated that South Africans are not aware of the benefits of rabbit meat.

Apart from lack of knowledge about rabbit meat, food habits are a component of culture that has a significant influence on the food decisions consumers make. Culture determines how people use a certain food and ultimately affects the intake of that food (Asp, 1999:288). With regard to rabbit meat, Dalle Zotte

(2002) points out that its consumption relies heavily on cultural, traditional and religious beliefs. Sonandi, Masika and Van Averbek (1996:432) report African beliefs which forbid the consumption of rabbit meat. These beliefs are associated with the pelt colour of the rabbits.

The fact that bush-meat has diminished over the last couple of years (Lukefahr & Cheeke, 1990) has made a significant contribution to small-scale farming in many developing countries (Gittens, 2000:52). Rabbit meat production is suitable for small-scale farming. This poses a challenge of how the total food production can be altered to improve the balance of nutrients available to the population (Garnier, Klont & Plastow, 2003: 83, Schneeman & Lupien, 2002), which is also an opportunity to address malnutrition, thus to improve food security and to derive economics benefits.

However, Asp (1999:289) notes that households require "normal" food for their meals. By "normal" is meant "familiar" food and implies set food behaviour patterns "liked foods are those that are familiar, considered pleasant, and are the ones eaten, thus food preferences predict consumption" (Asp, 1999:289, Voster & Hautvast, 2002).

According to Raharjo (1994) and Sloan (2002:46) factors such as gender, age and ethnic differentiation have a great impact on the personal eating styles of individuals. Regarding these issues, the limitations towards consumption of rabbit meat indicate a change in the eating habits pertaining to rabbit meat. Clearly, the eating habits of middle-aged consumers are relatively stable, the greatest influence comes from the young emerging generation which is more sensitive to all criticisms associated with meat (Dalle Zotte, 2002:14). Despite the fact that some consumers are shying away from rabbit meat due to traditional eating habits that are influenced by culture, religion, age and price, rabbit meat has become a favourite among the health-conscious consumers in other parts of the world (Dalle Zotte, 2002:11). This study aims at investigating the role of ethnicity on consumer choice of rabbit meat in a group of respondents in Western Cape (Figure 1). Results will be of importance for micro-enterprises and for marketing strategies.

7.2 Methodology

7.2.1 Research design

A quantitative research technique was used because this best suited the aim of the research. The purpose of the survey was to investigate the effect of ethnicity on the potential consumers' choice of rabbit meat in a town in the Western Cape. In order to meet this objective the descriptive survey method was employed using a structured questionnaire.

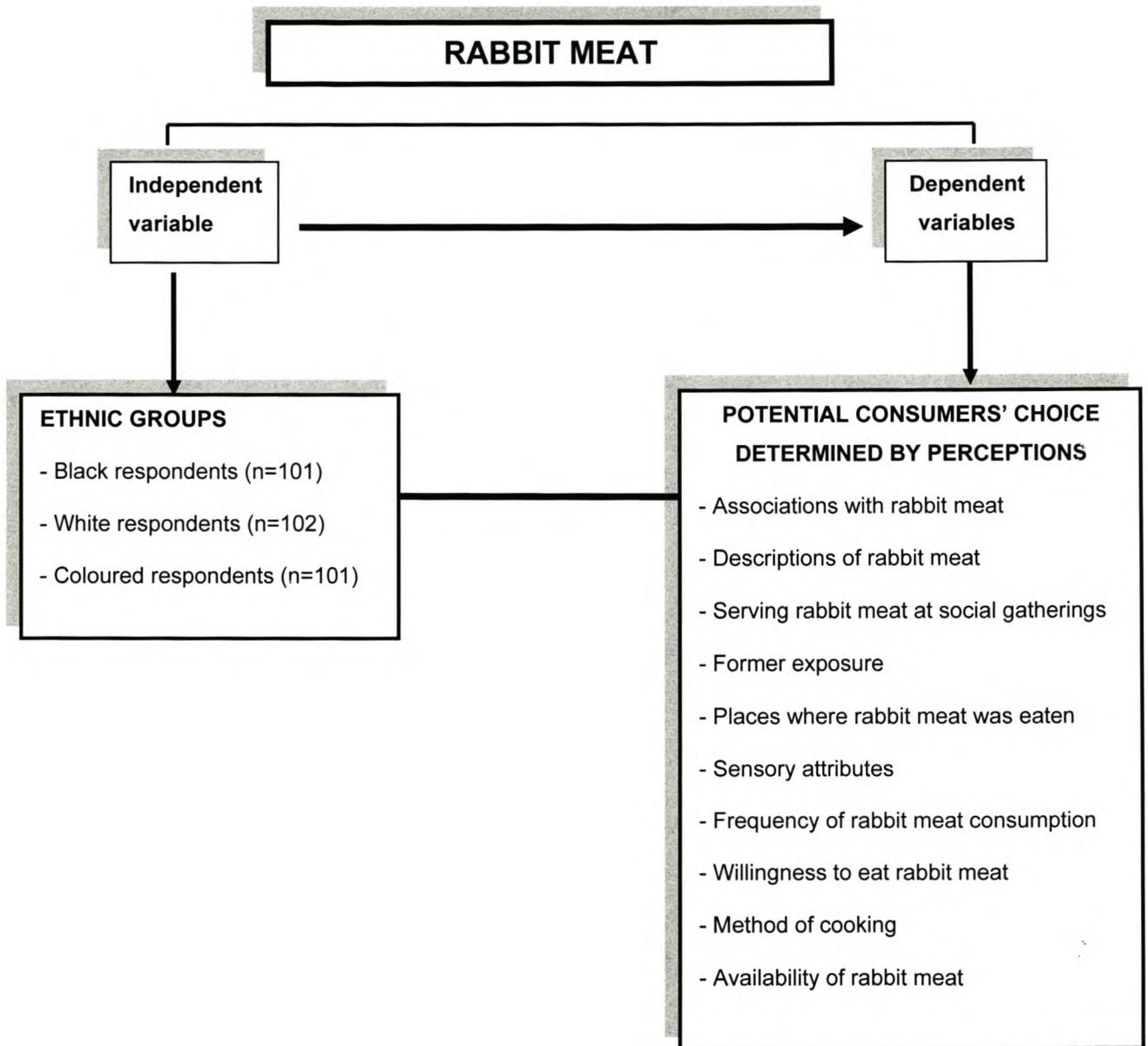


FIGURE 1 CONCEPTUAL FRAMEWORK OF STUDY DEPICTING THE INDEPENDENT VARIABLE AND DEPENDENT VARIABLE

7.2.2 Study population

The study population consisted of three racial groups (blacks, coloureds and whites) of different ages and various educational levels. A sample of 304 consumers was randomly drawn from the population residing in Stellenbosch area and a representation for each ethnic group (black respondents (n=101), coloured

respondents (n=101) and white respondents (n=102)) was used. To achieve a random selection the systematic sampling technique was used (Frankfort-Nachmias & Nachmias, 1996:187). This involved counting residential houses from property layout maps of Stellenbosch area, deciding on the number of respondents required from each area and dividing sample size by number of houses. The identified houses were marked on the area maps. To substantiate the map an address list was compiled. Interviews were conducted in Stellenbosch during May-June 2003. The areas included were Idasvalley, Cloetesville, Kayamandi, Uniepark, Mostertsdrift, Dalsig, Universiteitsoord, Lacoline, Kromriver, Die Boord, Paradyskloof and Onder-papegaaiberg.

7.2.3 Survey instrument

The survey instrument was designed to examine consumer attitude towards rabbit meat consumption. The dendrogram technique (Schutte, 1992) analogous to the conceptual framework explained by Frankfort-Nachmias and Nachmias (1996:33) served as a foundation for the design of the survey questionnaire. This technique was applied after the boundaries for the theory were defined during a comprehensive literature review and acted as a guide for asking relevant questions within the scope of study.

The survey instrument was divided into three parts. The first part was to be filled in by all respondents, the second part was meant for those who eat meat, even if they do not eat rabbit meat, while the last part was only for those who had eaten rabbit meat before or who were willing to eat rabbit meat if it was available. This division of the questionnaire in sections resulted in variation in the total number of respondents per question.

The preliminary questionnaire was evaluated by a panel from the disciplines of Animal and Consumer Sciences. The questionnaire was pre-tested by the researchers in the particular ethnic groups (5 from each group) amongst students on the campus of Stellenbosch University before collection of data commenced. Relevant changes were made on the questionnaire pertaining to these findings.

7.2.4 Data collection and organisation

Three well-experienced fieldworkers were used for the collection of data, after having been screened for suitability as interviewer in the particular area. They were given thorough training to minimise problems that may affect the reliability of the results.

The data obtained from the questionnaire were organised by coding the open-ended questions in order to prepare them for data capturing.

7.2.5 Data analysis

The data were entered into a *Microsoft Excel* spreadsheet. The quantitative data was then analysed to establish the means, standard deviations, frequencies and percentages using 8.2 version of the SAS package (1999). The statistical significance level between the dependent variable and independent variable were determined by Chi-square tests at $p < 0.05$.

7.3 Results and discussions

7.3.1 Demographic profile of respondents

The first six questions of the questionnaire were on the demographic attributes of the respondents.

7.3.1.1 Age

The results in Figure 2 reveal that the age of the respondents ranged from 20 years to 51+. More than half of the white respondents (65%) and the coloured respondents (54%) were in the age-categories above forty, while the black respondents (53%) were in the age categories 40 years and younger.

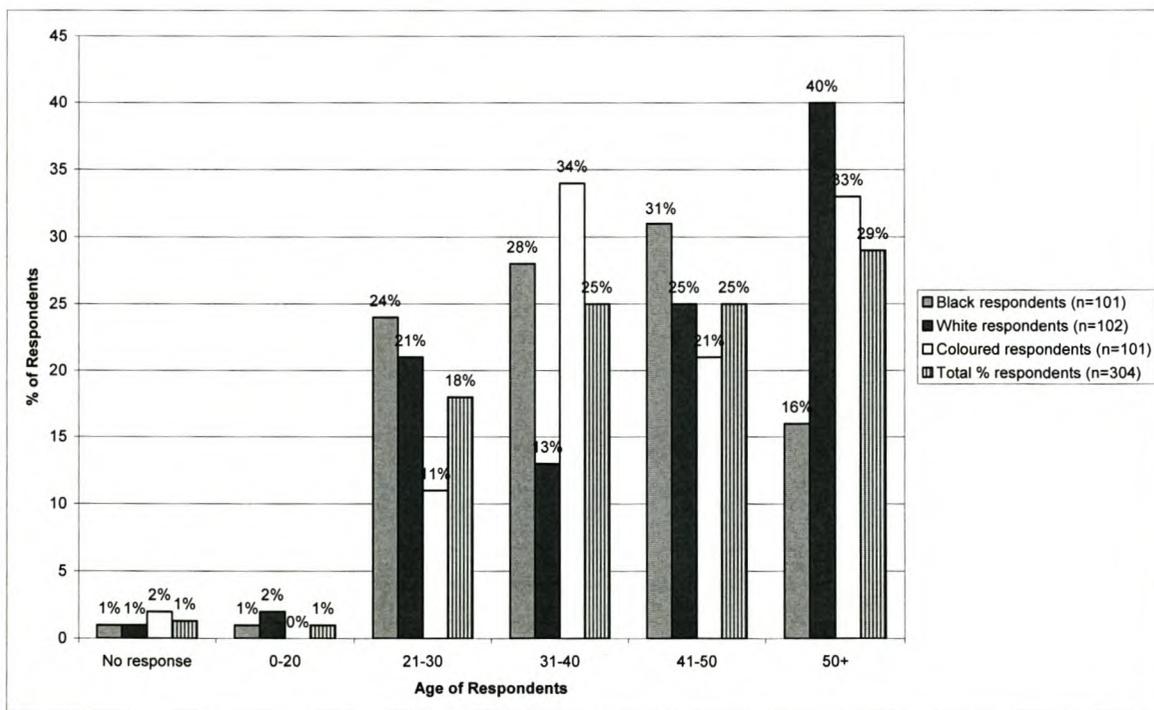


FIGURE 2 AGE DISTRIBUTION OF RESPONDENTS PER ETHNIC GROUP (n=304)

7.3.1.2 Gender

Although the intention of the researcher was to alternatively select respondents by gender in order to have male and female heads of household in a 1:1 proportion, the results show that 46% of the respondents were males and 54% were females (see Table 1).

TABLE 1 THE GENDER (%) OF RESPONDENTS

Gender	n	%
Female respondents	165	45.7
Male respondents	139	54.3
Total	304	100.0

7.3.1.3 Level of Education

Results revealed that the three ethnic groups differed significantly ($p < 0.01$) in terms of educational level. A large percentage (41%) of black respondents had primary education, while 43% had secondary education, and only 14% were educated at tertiary level. On the extreme end, 89% of white respondents had tertiary education, while there were no white respondents with only a primary education. With the coloured respondents, 67% and 16% had secondary education and primary education respectively and only 12% had tertiary education. In general, the largest percentage of respondents (39%) had secondary education, although 37% of the respondents had tertiary training. Only 19% of the sample had limited education at primary level (Figure 3).

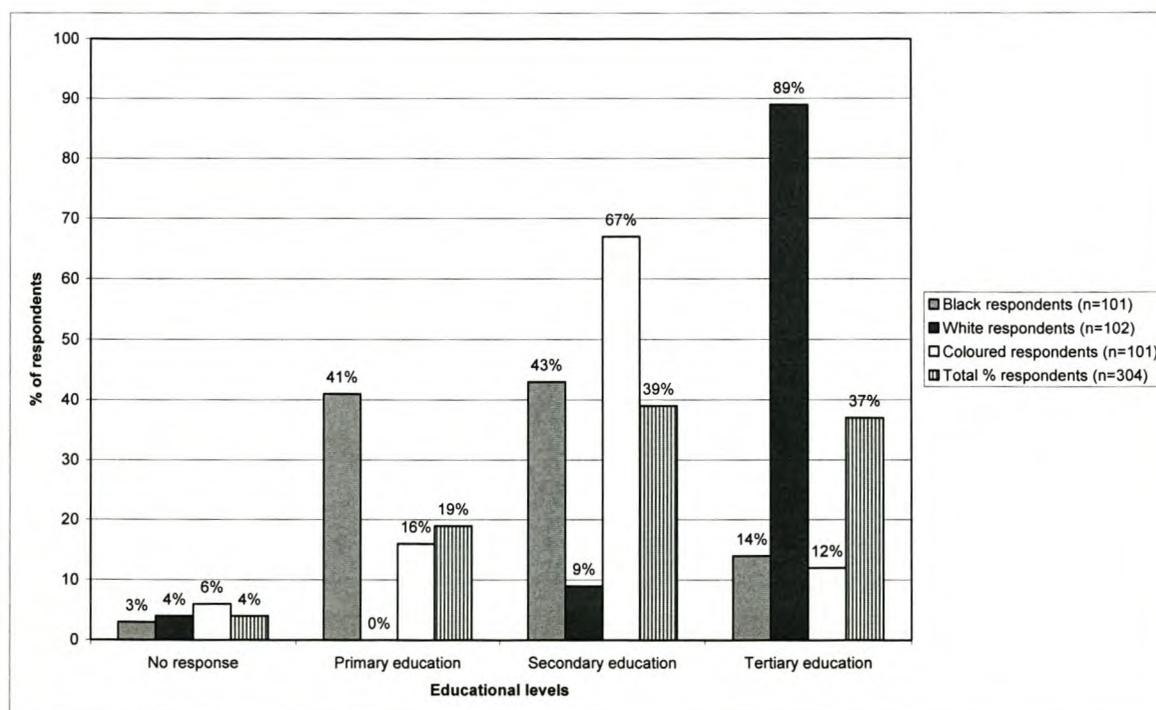


FIGURE 3 DISTRIBUTION OF EDUCATION LEVEL OF RESPONDENTS (n=304)

7.3.1.4 Religion

The three ethnic groups (n=304) did not differ significantly ($p>0.05$) in their religious beliefs. In fact, 96% of all respondents were Christians.

TABLE 2 FREQUENCY DISTRIBUTION OF RELIGION OF RESPONDENTS (N=304)

Religion	Ethnic groups			(n)	(%)
	Black respondents (n)	White respondents (n)	Coloured respondents (n)		
No response	0	3	2	5	1.6
Christian	100	94	97	291	95.7
Moslem	0	1	0	1	0.3
Hindu	0	1	0	1	0.3
Other	1	3	2	6	1.97
Total	101	102	101	304	99.9

The total does not add up to 100%, because of the rounding off of the decimal point.

7.3.1.5 Income

Although 25% of the respondents did not indicate their monthly income due to unemployment and the overall feeling that income should be confidential, there was a significant difference ($p<0.01$) in the income of these three ethnic groups (Figure 4). White respondents dominated the highest category (R1701+) of monthly household income (52%), thereafter followed coloured respondents (7%). No black respondents earned in this category of household income. In the highest six categories of household income (above (R1 200) the black respondents were limited to one income category, namely in the R1 301-R1 400. At the lowest level of income (0–R500), the majority of the respondents were black (34%), followed by coloured respondents (22%), while 2% were white respondents.

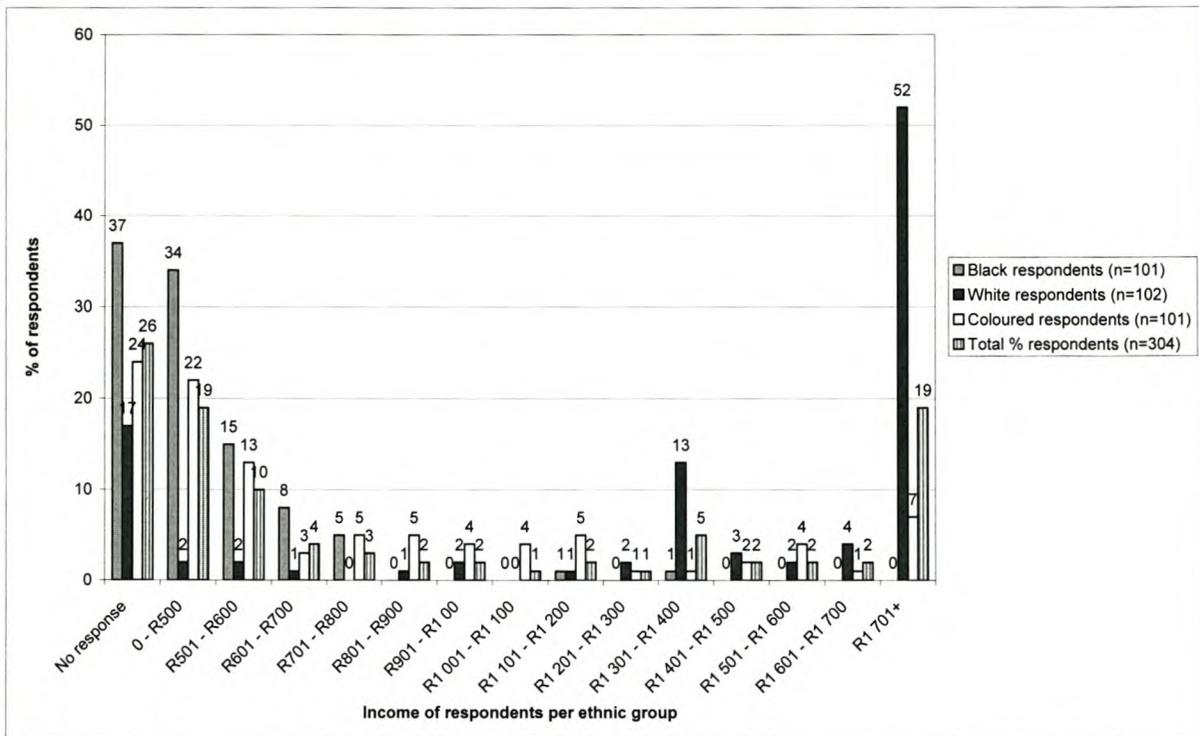


FIGURE 4 INCOME OF BLACK RESPONDENTS, WHITE RESPONDENTS AND COLOURED RESPONDENTS RESIDING IN STELLENBOSCH (n=304)

7.3.2 Potential consumers’ choice determined by perceptions

7.3.2.1 General associations

In response to the question on “*what comes to their mind when rabbit meat is mentioned?*” a variety of answers were recorded (Figure 5). Among all the concepts identified, associating rabbits with pets and not as meat-producing animals seemed to be most common amongst the white respondents (40%), whilst only 10% coloured respondents and 9% black respondents associated a rabbit with a pet. A significant difference ($p < 0.01$) between ethnic groups was found regarding this association. This fact was reported by Lukefahr and Cheeke, (1990) as the major constraint in successful rabbit meat farming, and possibly gives one reason why some consumers have indicated that it is a strange idea to eat rabbit and that they have not eaten it before (14%).

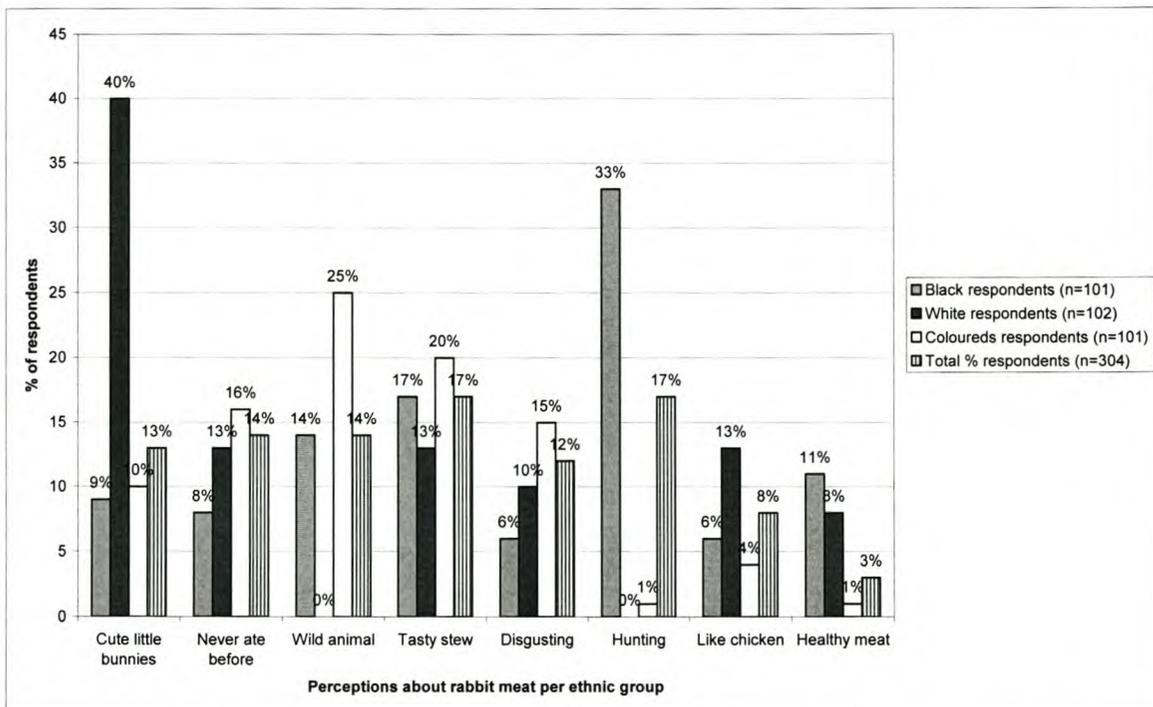


FIGURE 5 CONCEPTS DISCLOSED BY SOUTH AFRICAN RESPONDENTS THAT COME TO MIND WHEN RABBIT MEAT IS MENTIONED (n=304)

On the other hand, black respondents (33%) associated the rabbit with hunting in the rural areas. None of the white respondents, and only 1% of the coloured respondents, had this association with hunting. This was a well-established practice reported by Prayaga and Eady (2000), but had a sustained decline in Australia, offering scope for rabbit farming as a rural industry not only in Australia, but also in South Africa.

About 17% (n=51) of all the respondents said rabbit meat is very tasty, and that it tastes like chicken breast. Lukefahr (2002) encourages the elevation of the stature of the rabbit as a significant “niche” livestock species to benefit humanity through the expansion of sustainable, small-scale rabbit farming and or development projects. Cooperative extension agents elsewhere in the United States of America have 50 growers providing processed meat, such as smoked and marinated options and rabbit fryers as well as rabbit sausages are being explored. However, there were other respondents (12%, n=36) who disclosed that they were not at all interested in the idea of eating rabbit meat. If innovative products could be investigated a change may occur.

7.3.2.2 Agricultural products associated with rabbits

In response to the question “*what agricultural products do you associate a rabbit with*”, their associations varied (Figure 6). Although a high percentage (70%) of black respondents associated the rabbit with meat (Figure 6), only 30% coloured respondents and 29% white respondents had the same concept. This

confirms the findings by Lamar (1998) that rabbit meat consumption is much easier to develop where consumers are already used to eating widely different kinds of meat, such as that obtained from hunting. Rabbit meat, amongst the black respondents is therefore a “normal” food, and better accepted (Asp, 1999). This would be generally true of black Africa, and poses a challenge for marketing in ethnic groups where it is not properly established as meat. In fact, Batish, Kaur and Dhillon (1998) report marketing problems as a major constraint in the establishment of economic activities, i.a rabbit farming, of rural woman.

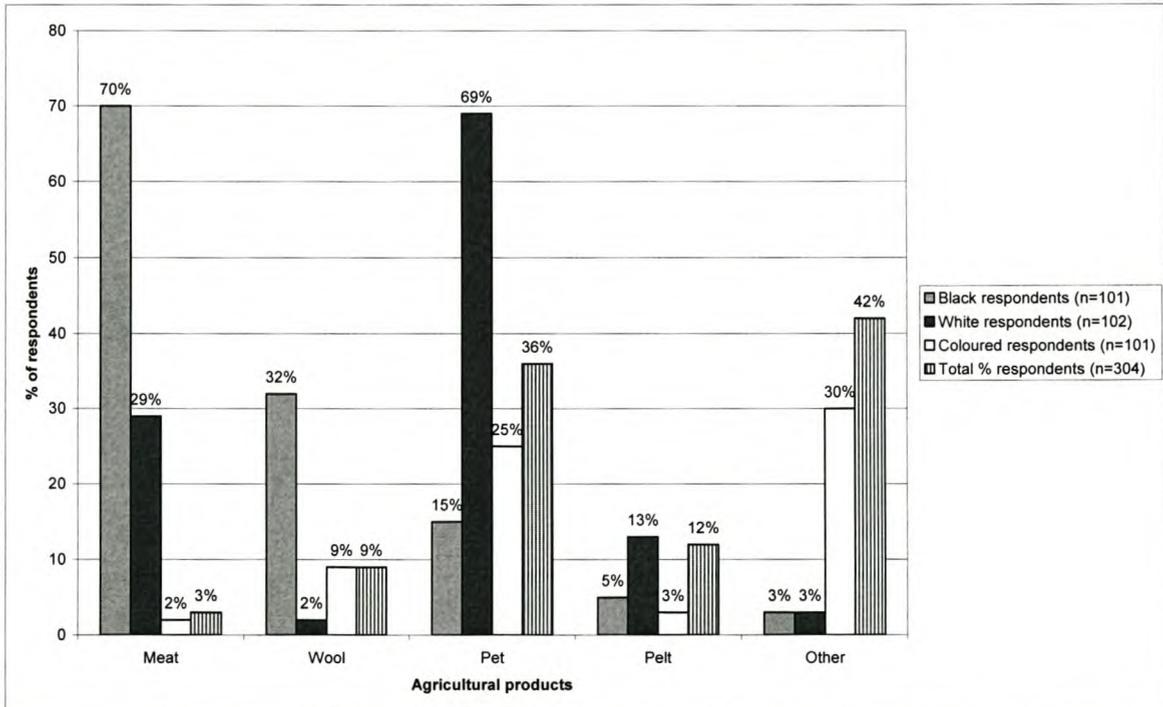


FIGURE 6 PERCEPTIONS OF THE ETHNIC GROUPS ON THE AGRICULTURAL PRODUCTS ASSOCIATED WITH RABBIT (n=304)

Another product associated with the term rabbit was that of wool where 33% of the black respondents had this association compared to only 5% for both white respondents and coloured respondents. The differences in this association between the black, white and coloured respondents was significant ($p < 0.01$).

7.3.2.3 Descriptions given for rabbit meat

In response to the question “would you describe rabbit meat as meat from an unclean animal, for the poor, for the rich or as health meat” the majority of white respondents (62%, n=64) regarded it as unclean meat, while only 2% of the black respondents gave this response (Figure 7). Although Sonandi et al. (1996) documented that some religious denominations associate rabbit meat with the meat of an unclean animal

such as pork, the results of this study displays that 88% (n=254) of Christian respondents indicated that they were not forbidden to eat rabbit meat.

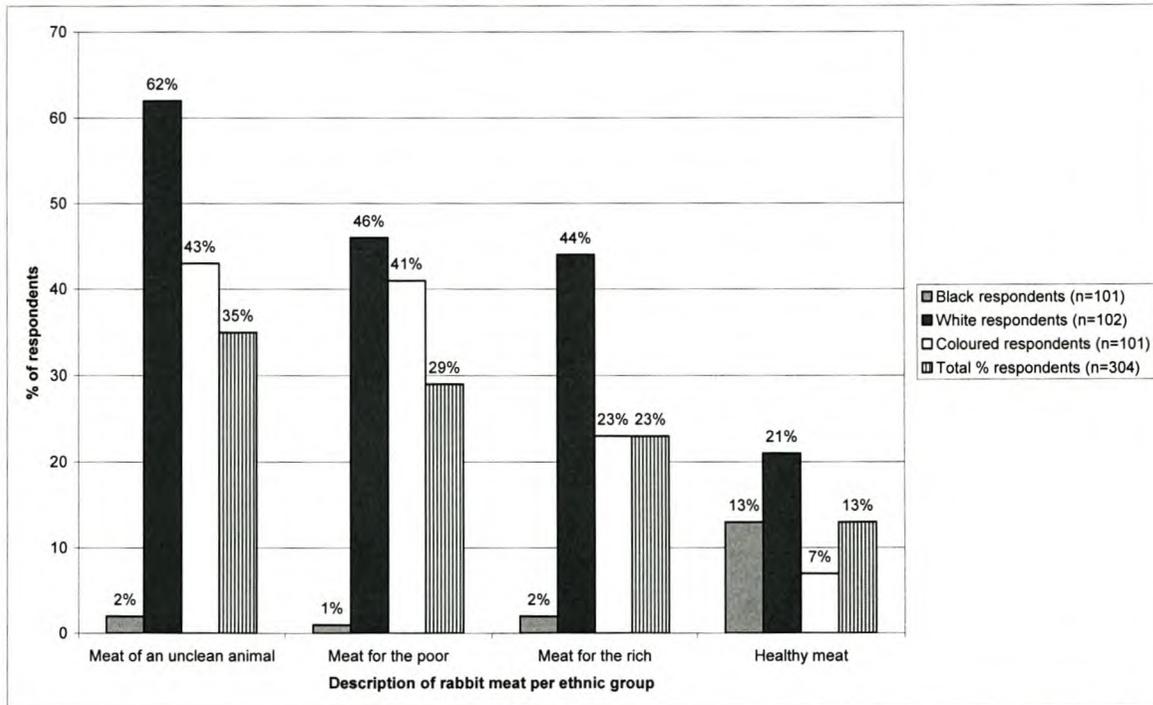


FIGURE 7 RESPONSES OF ETHNIC GROUPS TO DESCRIPTIONS OF RABBIT MEAT (n=304)

Whether rabbit meat was for the *poor* or the *rich* draw similar responses from white respondents (46% versus 44%). Seemingly there was no income stratification associated by whites with rabbit meat. The coloureds had nearly twice the number of respondents associating rabbit meat with meat for the poor (41% versus 23%). In this regard Gittens (2000) reported that Ciskei Rabbit Production Corporation was established in an attempt to promote small-scale farming for affordable meat in the Eastern Cape. This project was considered appropriate for poor people in the rural areas as it contributes to increasing the family income while providing high quality meat at low cost.

About 13% (n=40) of the respondents said that rabbit meat is healthy. They stated that its healthiness is due to the fact that it is highly nutritious (15%, n=44), even though they made it clear that they were not aware of the specific nutrients. Other studies revealed that in comparison with the meat of other species, rabbit meat is in fact richer in proteins and certain vitamins and minerals (Bernadini, Castellini & Lattaioli, 1994). Some respondents (7%, n=22) mentioned that rabbit meat is low in fat, and a few (1%, n=4) said it contains less cholesterol than red meat.

The health concept of rabbit meat was elaborated on by few black respondents who believed that this results from the fact that rabbits feed on grass, bulbs and herbs which consequently make the meat

“cleaner”. This is regarded as a misunderstanding as other animals, e.g. sheep and cattle, also eat the same diet. Among other health benefits mentioned by blacks was that traditional doctors use it as a medication to heal. Black respondents also mentioned that rabbit meat has the capacity to reduce high blood pressure. The lower sodium found in rabbit meat by Nkhabutlane, Hoffman and Vosloo (2003) and the positive profile of fatty acids recorded on the two types of breeds supports this view (Nkhabutlane et al., 2003).

7.3.2.4 *Serving rabbit at social gatherings*

When consumers were asked “Do you think rabbit meat can be served at a social gathering such as a religious gathering?”, approximately 57% (n=173) felt that rabbit meat is meat like all other meats and serving it at a religious setting should depend totally on the agreement of members of that particular group (Figure 8). Those who were against the idea (33%, n=99), argued that rabbit meat is strange- not “normal” (a term used by Asp, 1999) to most people and that churches could not allow consumption of game meat. Others said a rabbit is too small, so serving it for a large gathering will call for too many rabbits to be slaughtered, and thus encourage killing of many innocent animals.

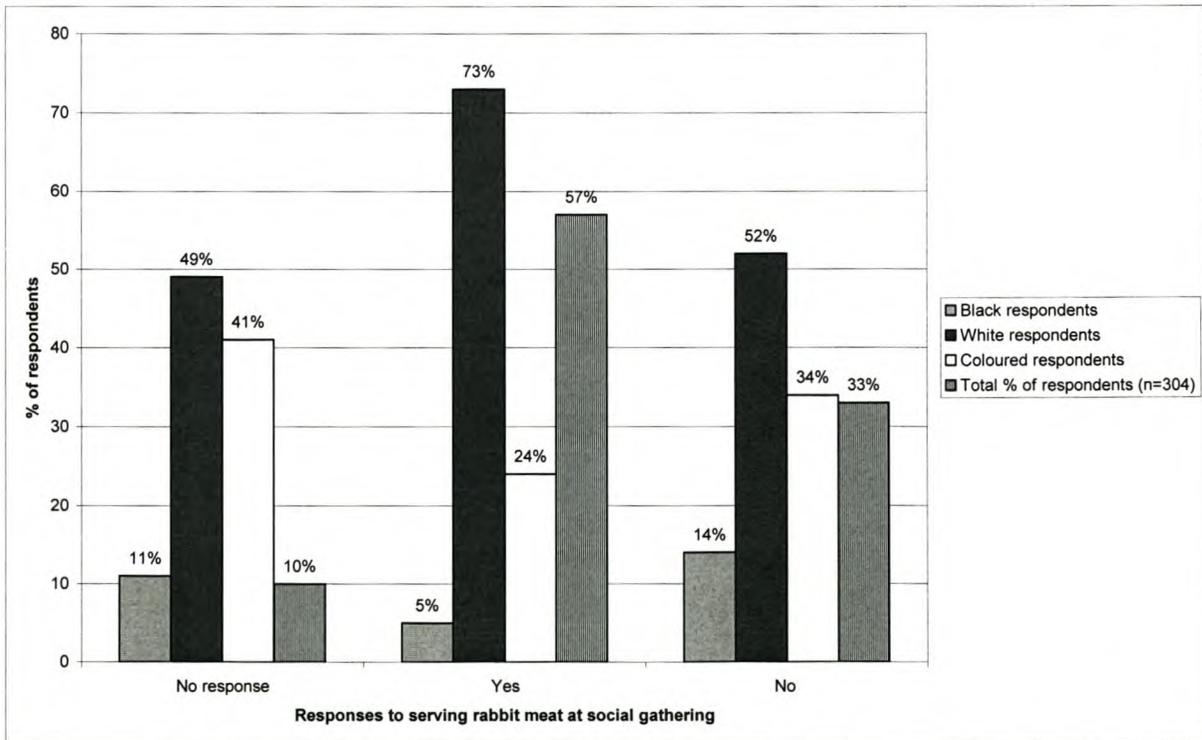


FIGURE 8 RESPONSES OF DIFFERENT ETHNIC GROUPS TOWARDS SERVING RABBIT MEAT AT SOCIAL GATHERING (Yes/No) (n=304)

7.3.2.5 Superstitions associated with rabbit in a culture

The respondents were asked “whether there are any superstitions associated with rabbit meat in their culture”. There was a significant difference ($P < 0.01$) between ethnic groups concerning superstitions and traditional beliefs (Table 3). According to these results, white respondents ($n=102$) and coloured respondents ($n=101$) did not have superstitions and cultural beliefs associated with consumption of rabbit meat, while consumption of rabbit meat could be influenced by 37% of the black respondents, due to their traditional beliefs. Even though the production of rabbit meat has more potential than the production of fur in South Africa, traditional beliefs are a limiting factor in marketing rabbit meat. This view is supported by Gittens (2000).

Sonandi et al. (1996) also found that, although in South Africa 79% of Xhosa people could eat rabbit meat, they culturally considered it to be suitable for boys not for women and girls, as it is believed to cause sterility and abortion. Some respondents in this study felt that if pregnant women continue to eat rabbit meat, they would give birth to children who always cry. According to black respondents, boys and men are the ones who hunt the rabbit. This further adds to the cultural belief that it is a boy's and man's food that is eaten out in the *veld*.

TABLE 3 EXISTENCE OF SUPERSTITIONS ABOUT RABBIT MEAT IN DIFFERENT ETHNIC GROUPS

Are there superstitions?	Ethnic groups			Total respondents (n=304)	Total % respondents
	Black respondents (n=101)	White respondents (n=102)	Coloured respondents (n=101)		
No response	4	1	5	10	3
No	60	100	95	255	84
Yes	37	1	1	39	13
Total	101	102	101	304	100

Among other traditional beliefs identified, it was stated that a rabbit is a fearful animal and eating more of its meat will make one fearful as well. According to the Xhosa culture, every black African belongs to a certain group of animals and a rabbit is an animal for a group of people called Amavundla. These people respect it, and cannot eat it. They perceive it to be a human being (one of them).

From these results it was also found that Xhosas shy away from other types of rabbit breeds because they are associated with witch-craft, particularly those rabbits with reddish ears referred to as “Kolani” in Xhosa. Some black respondents indicated that the fearful behaviour of wild rabbit resulted from being

troubled by hunters. In this case a rabbit was referred to as an orphan, which means “never happy”. With this concept in mind, Xhosas believe that rabbit meat should be cooled - anybody who eats it warm will stay fearful like a rabbit. If someone has big ears and is fearful, they refer to him as a rabbit. Sonandi et al. (1996) also found that Xhosas have the superstitious concept that if a child eats rabbit meat, his or her mouth and lips might grow to be like those of the rabbit. This may be used as an explanation for the finding by Gittens (2000) why some families do not let their children eat rabbit meat

The respondents were also asked if, *according to their cultural beliefs, there is a taboo associated with the colour of the fur of a rabbit*. The general feeling among respondents (77%, n=121) who consume rabbit meat was that the colour of the fur could not influence the decision to purchase rabbit for meat. However, 16% (n=25) believed that the colour of fur could contribute to their choice, and brown colour was recorded as the favourite for the majority (12%, n=19) on the basis that they produce fatty meat and for the fact that they look wild and very familiar. A small number of respondents who consume rabbit meat (n=6) argued that although white rabbits look like pets, white is an indication of cleanliness so they would prefer white rabbits. This explains the popularity of the New Zealand White and California breeds in the rabbit meat industry, both of which are albino whites with pink eyes. Gittens (2000) mentions that in some cases a processor may simply prefer the cleaner white meat from the albino breeds.

In response to the question “*would the colour of the rabbit’s eyes influence your choice of rabbit meat*” the majority of respondents who eat rabbit meat (84%, n=132) were not influenced by the colour of rabbit eyes. The few who felt that their choice would be influenced (16%, n=25) had a perception that the pink-eyed rabbits are perceived of not being dead and 3% (n=2) argued that they can only eat rabbit with brown eyes because of appealing appearance. There was also a feeling amongst a small group of respondents (3%, n=20), that brown eyes are normal and common and that they look “honest”. On the other hand it was mentioned that pink eyes are associated with pets (n=5) and only two respondents felt that they indicated sickness. These results are in agreement with Green (1996) and Gittens (2000) who reported that some African cultures forbid the consumption of New Zealand White due to the albino appearance – the reason being that pink-eyed rabbits will bring them bad luck. With this in mind Sandford (1986), Green (1999) and Sell (2002) noted that using albino-eyed (pink-eyed) rabbits for commercial meat-producing purposes may not be economical. According to Gittens (2000), consumers of rabbit meat do not have a problem with white rabbits, their main problem is with the colour of eyes. Thus Nyete, manager of the Ciskei Rabbit Production Corporation, as cited by Gittens (2000) stated that they crossbreed in order to come up with brown-eyed rabbits that are accepted by local people.

7.3.2.6 The respondents’ position with regard to meat consumption

Respondents were also asked to *indicate whether they eat meat or not* as it was anticipated that the total percentage of vegetarians in any community could significantly influence marketing of all meat types. A majority of the respondents (92%, n=279) seemed to have no problem with meat (Table 4).

TABLE 4 GENERAL CONSUMPTION OF MEAT ACCORDING TO ETHNIC GROUP

Do you eat meat?	Ethnic groups				%
	Black respondents	White respondents	Coloured respondents	Total respondents	
No response	1	3	6	10	3
Yes	90	96	93	279	92
No	10	3	2	15	5
Total	101	102	101	304	100.0

7.3.2.7 The respondents' position with regard to rabbit meat consumption

Respondents were asked "have you ever eaten rabbit meat before?" According to these results 47% (n=142) have eaten rabbit meat before, while 52% (n=158) have never eaten rabbit meat (Figure 9). The remaining percentage (1%) did not respond to this question.

Significant differences were found between males and females ($p \leq 0.01$), regarding past experience on the consumption of rabbit meat. More males (55%, n=78) have had rabbit meat before than females (39%, n=55). The results also showed highly significant influence of ethnic groups ($p \leq 0.02$) regarding experience of eating rabbit meat. Of the total number of respondents who have had rabbit meat before, the highest percentage (62%) was predominantly black respondents followed by 44% white respondents and 36% coloured respondents (Figure 9).

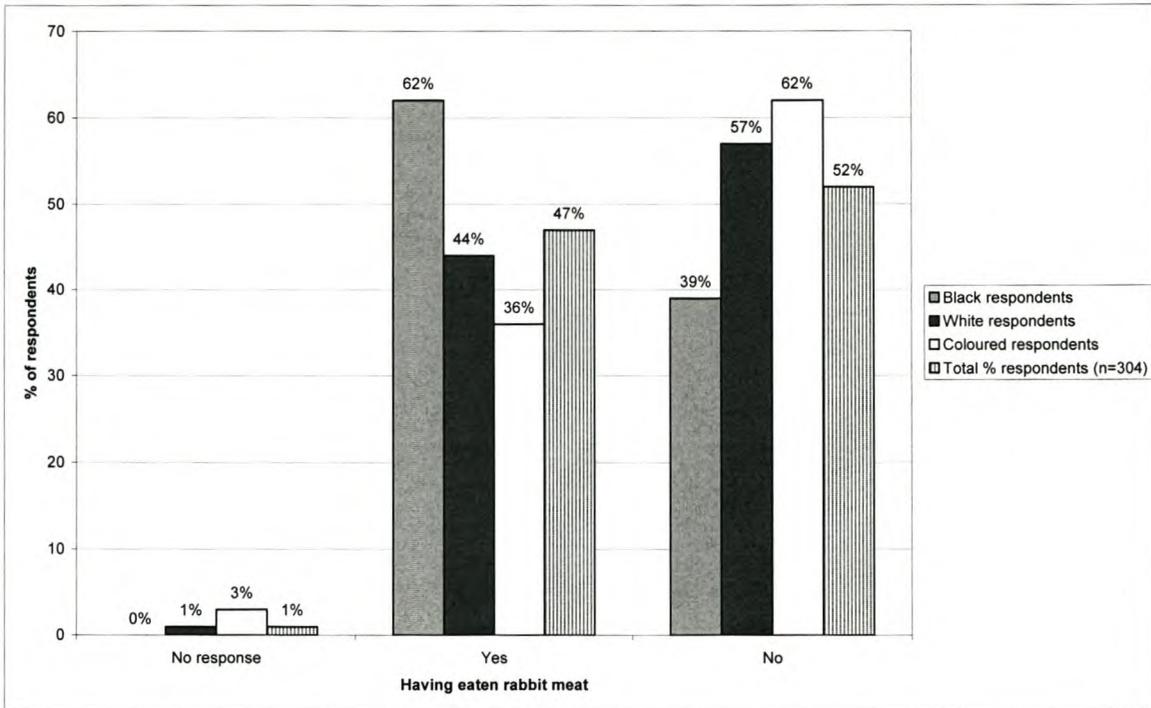


FIGURE 9 TOTAL PERCENTAGES OF RESPONDENTS INDICATING TO WHETHER THEY HAD EATEN RABBIT MEAT BEFORE OR NOT (n=304)

7.3.2.8 Access to rabbit meat

From the total number of respondents (n=304), 15% (n=46) indicated that it was difficult to access rabbit meat as it is not readily available in South Africa. This could possibly be linked to the reasons why 10% (n=29) never thought about eating it. Some respondents (6%, n=17) felt that introducing the concept of rabbit meat was not at all a good idea because rabbits are pets and in African culture they are considered human and thus not suitable for consumption. This may be the reason why some respondents (2%) have indicated that they were forced to eat rabbit meat when they were young and they would never eat it again. In addition to this, some were vegetarians (n=2) while others could not eat rabbit meat, due to religious reasons (n=3).

7.3.2.9 Place where rabbit meat was consumed

Respondents were required to "indicate the place where they had eaten rabbit meat". According to these results, an above-average percentage (65%, n=92) indicated that they ate it at home, 15% (n=20) in a restaurant and only a few respondents (8%, n=11) had it in both a restaurant and at home (Figure 10).

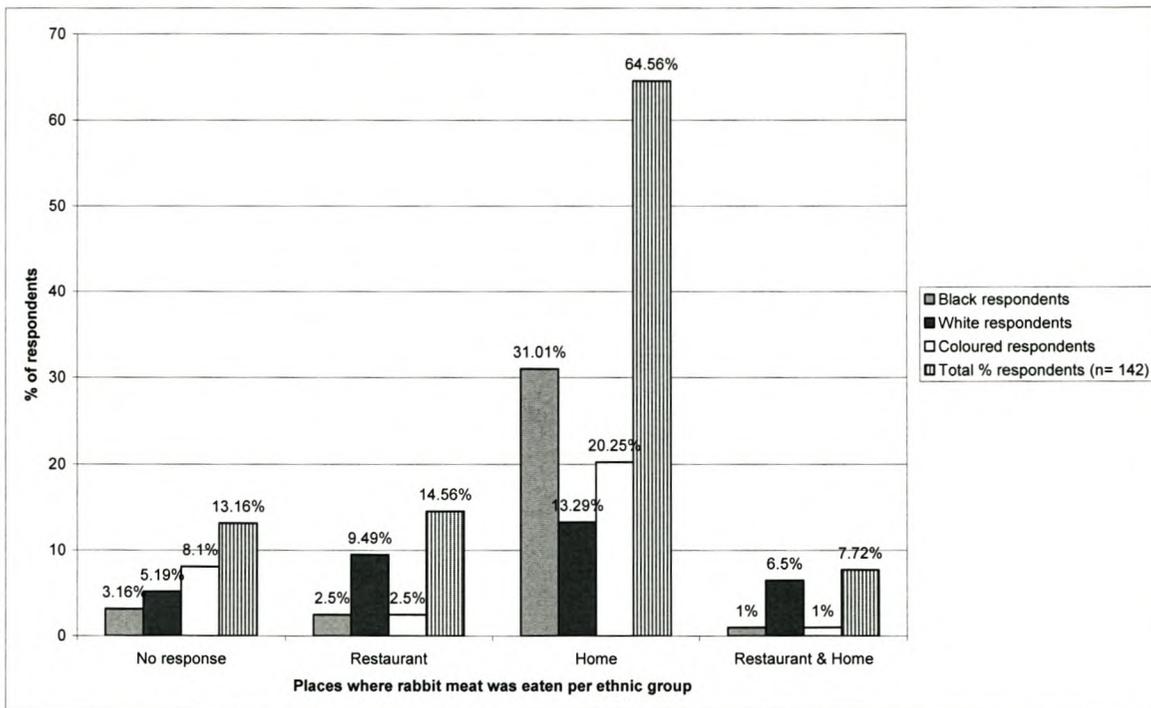


FIGURE 10 PLACES WHERE RABBIT MEAT WAS EATEN BY DIFFERENT ETHNIC GROUPS (n=304)

The three ethnic groups differed significantly ($p < 0.01$). More black respondents (31%, $n=44$) had rabbit meat at home than coloured respondents 20% ($n=29$) and white respondents 13% ($n=19$). Respondents who had rabbit meat in a restaurant were predominantly white respondents (15%, $n=21$).

7.3.2.10 Liking /Dislike of rabbit meat

Figure 11 illustrates a significant difference between ethnic groups ($P \leq 0.02$) regarding liking or disliking the meat, 69% ($n=97$) of $n=142$ respondents who ate rabbit meat liked the meat, and they were respectively 29% ($n=41$) black respondents, 18% ($n=25$) white respondents and 22% ($n=31$) coloured respondents. None of coloured respondents disliked the meat.

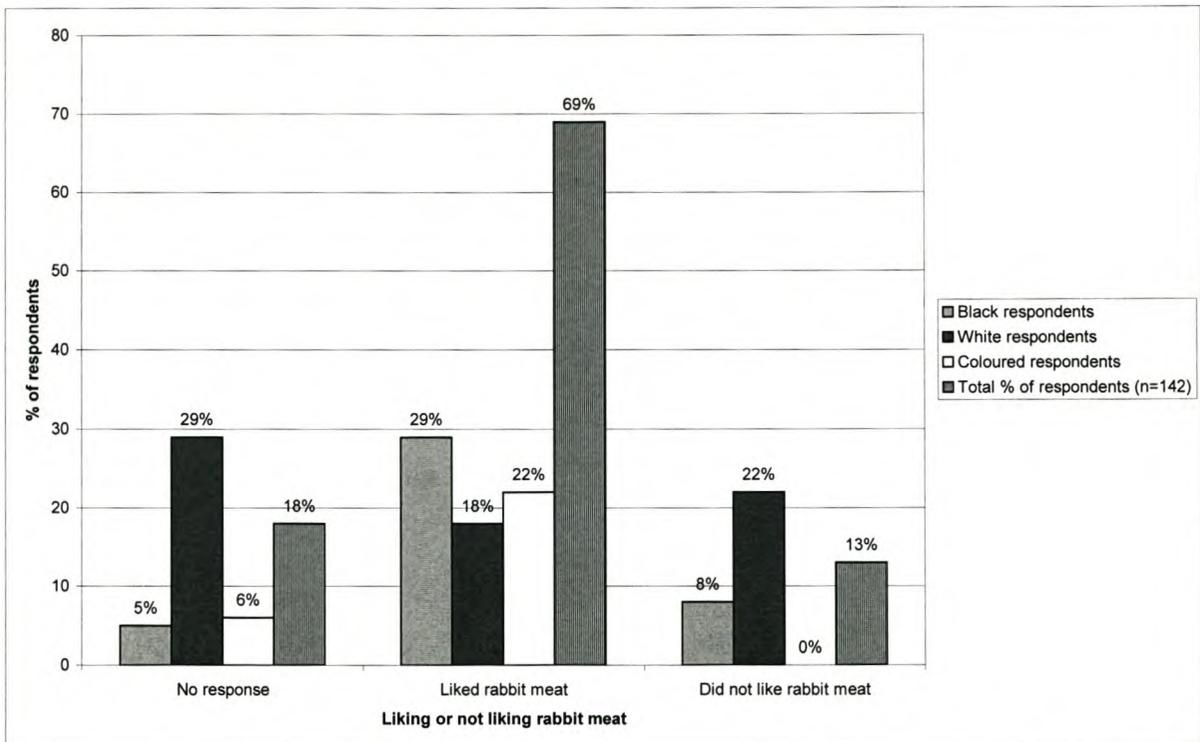


FIGURE 11 PERCENTAGE DISTRIBUTIONS OF RESPONDENTS THAT LIKED OR DISLIKED RABBIT MEAT (n=142)

It was therefore very important to note the reasons that made them like or dislike the meat. The responses regarding the factors contributing to the liking of rabbit meat is summarised in Figure 12. Taste constituted nearly half of responses (50%, n=71). Possibly this comment is associated with the familiarity of the black respondents with rabbit meat, which promotes acceptance (Asp, 1999). This was followed by texture, flavour and colour in decreasing order (Figure 12).

Black respondents who did not like rabbit meat, complained about its wild flavour. This finding is supported by a report of FAO (1999) that a large number of the South African population, in particular the African population, grew up eating rabbit meat from hunting in the veld and thus associate a rabbit with wild life. On the other hand, the white respondents (5%, n=7) disliked the idea of eating rabbit meat because they associated a rabbit with a pet, it did not reflect cultural tradition and was disliked, a food behaviour explained by Asp (1999).

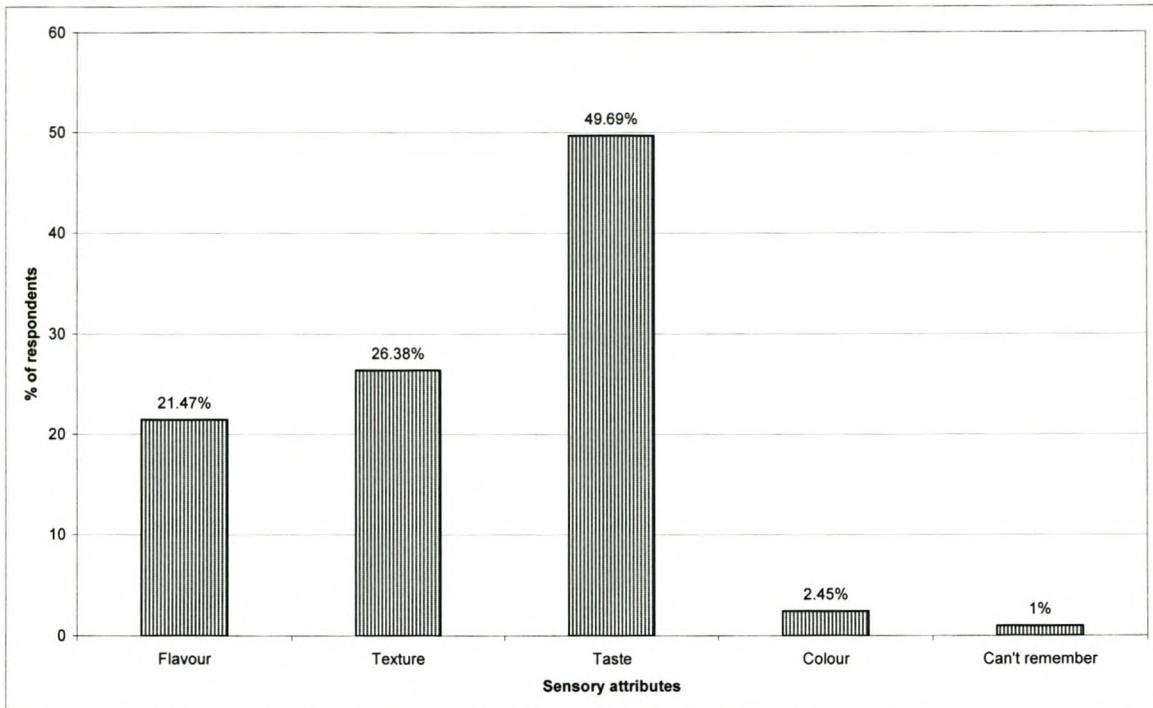


FIGURE 12 REPORTED SENSORY PROPERTIES THAT CONTRIBUTED TO LIKING OF RABBIT MEAT (n=142)

7.3.2.11 *Frequency of eating rabbit meat*

Although the respondents indicated that rabbit meat was not available, 19% (n=16) indicated that they do eat rabbit meat once a month, while the same percentage (19%, n=16) eat it twice a month, 13% (n=11) eat it once in six months, and 40% (n=34) were able to eat rabbit meat once a year (Figure 13). Due to its scarcity some respondents (9%, n=8) stated that although they had eaten rabbit meat before, it was a long time ago.

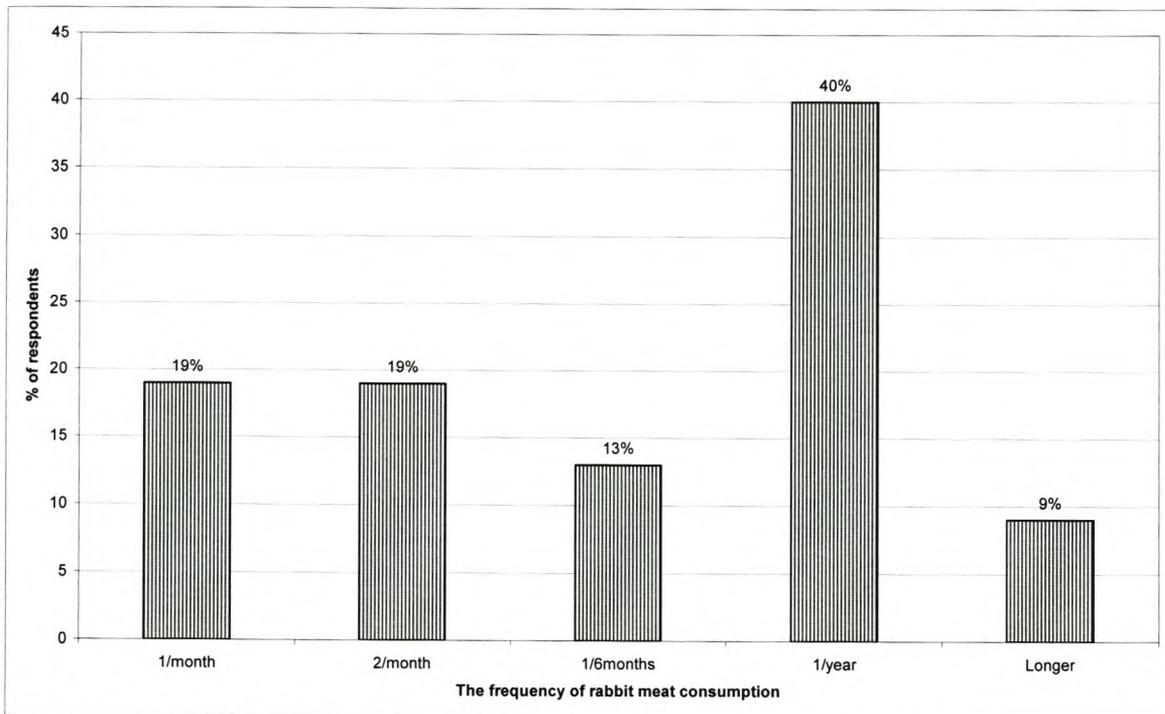


FIGURE 13 FREQUENCY OF EATING RABBIT MEAT (n=84)

7.3.2.12 *Willingness to eat rabbit meat if available*

From a marketing perspective one important question was asked, namely *whether they were willing to eat the meat if available?* Approximately 46% (n=73) of the respondents were willing to eat rabbit meat if available (Figure 14). The three ethnic groups differed ($p < 0.01$) in this regard. It is important to note that these results are in proportion to the information in Figure 9, in that the people in the ethnic groups with little experience of rabbit meat (the white respondents) were more optimistic about eating rabbit meat.

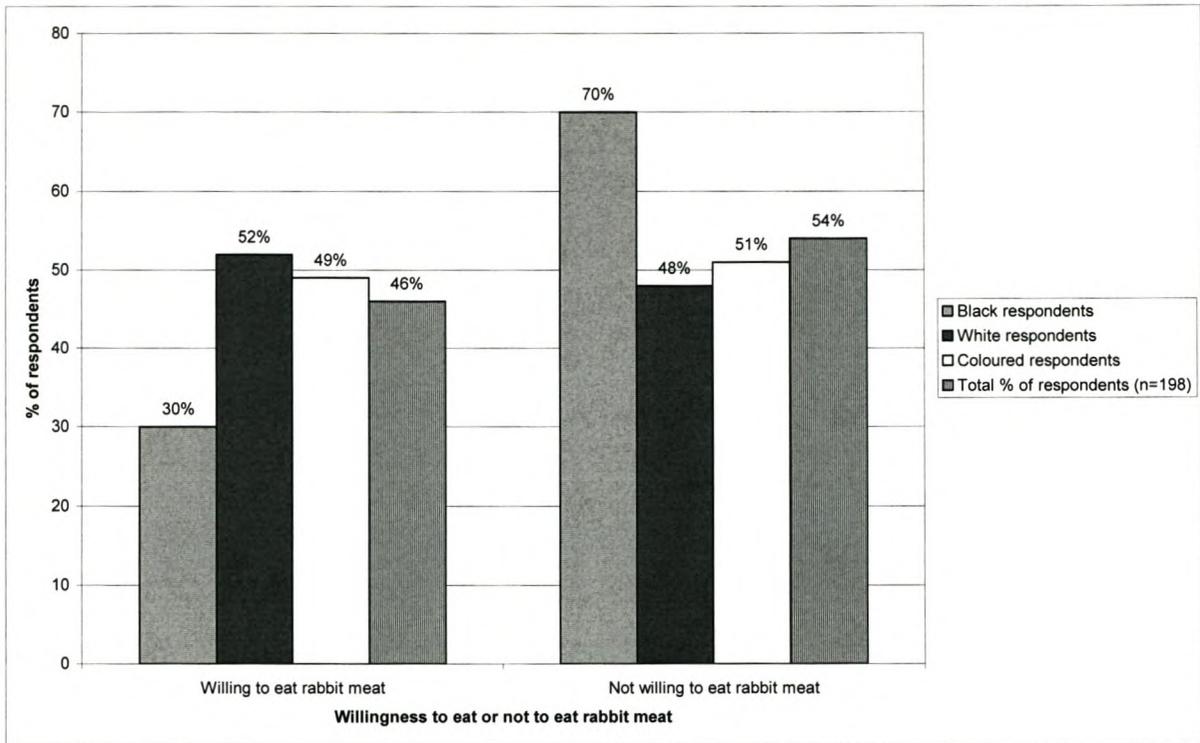


FIGURE 14 PERCENTAGE DISTRIBUTION OF ETHNIC GROUPS ON THEIR WILLINGNESS TO EAT RABBIT MEAT (n=198)

7.3.2.13 *Cooking method applied for the rabbit meat that was consumed*

Respondents were asked to indicate the method of cooking that was applied to the rabbit meat which they had consumed before because the attitude towards a food product may to a large extent be affected by the method of cooking. A majority of the respondents (49%, n=69), indicated that they consumed boiled rabbit meat followed by those who had fried (25%, n=36), roasted (25%, n=35) and stewed (23%, n=32) rabbit meat (Figure 15).

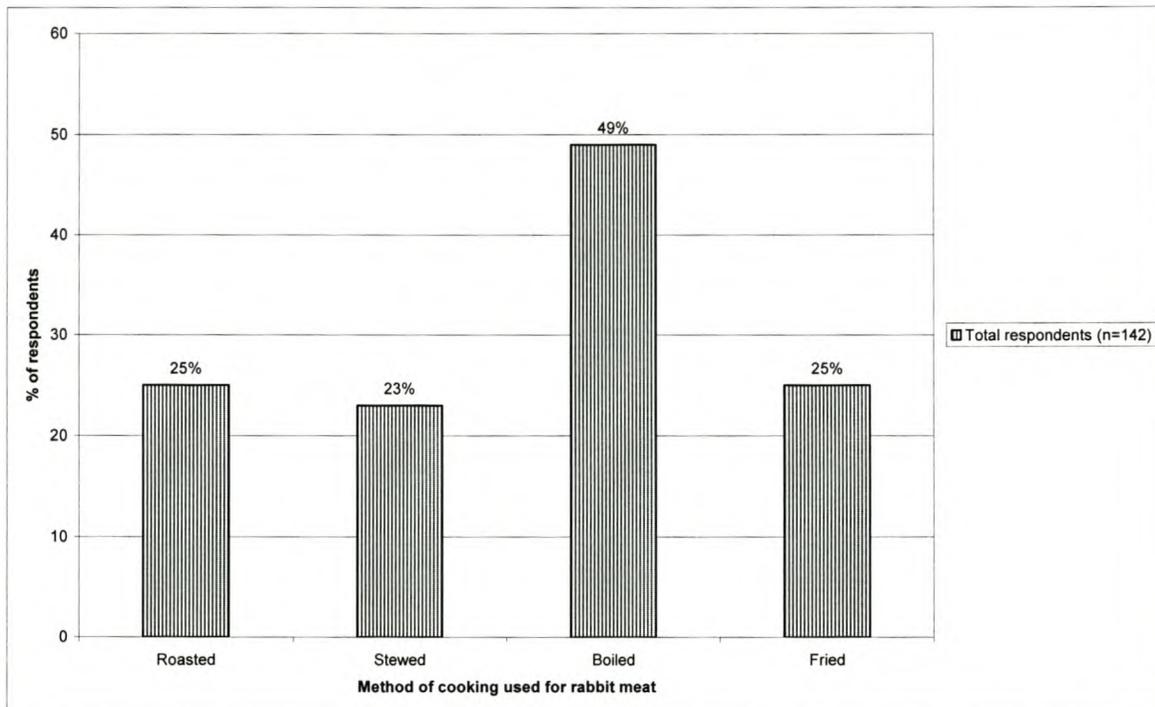


FIGURE 15 THE COOKING METHOD APPLIED TO THE RABBIT MEAT (n=142)

It appeared as if most of the respondents were not fussy about the method of cooking rabbit meat since the results displayed that a larger percentage (59%, n=95) felt there is no specific, correct method for cooking rabbit meat, while a significantly smaller percentage agreed that there are methods of cooking that are specifically suitable for rabbit meat (Figure 16).

Those who felt that there were certain methods suitable for cooking rabbit meat, were further asked to rate the suitability of the methods on a scale of 1-9 from least suitable to most suitable. According to Figure 16 the rating in terms of suitability was stewing, grilling, roasting, boiling, braising and frying in descending order. Fielding (1991) noted that the most suitable methods of cooking rabbit meat are dry methods of cooking, in particular which were rated poorly in this study, possibly because rabbits reared for the market will differ to wild rabbits with regard to cooking method. Rabbit meat may also be used for stews, but care must be taken to avoid overcooking as it can cause the meat to lose its structure.

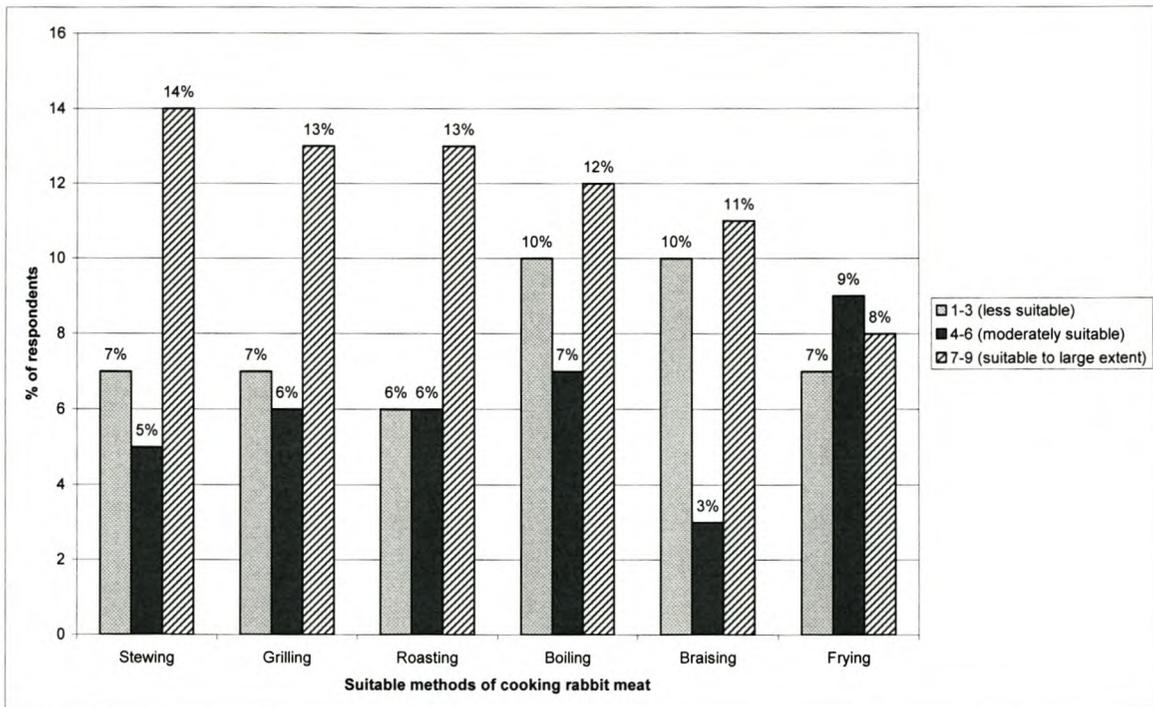


FIGURE 16 THE METHOD SUITABLE FOR COOKING OF RABBIT MEAT (n=156)

7.3.2.14 *Availability rating by respondents for rabbit meat in South Africa*

The respondents were asked “*whether rabbit meat is available in South Africa*”, to which 60% (n=94) of respondents (n=156) said it was available, 37% (n = 58) indicated that it is not available, the other 3% (n=4) did not know. The differences in ethnic groups were highly significant (p<0.01) (Figure 17). The respondents that agreed that rabbit meat is available in South Africa were predominantly black respondents (97%, n=58), followed by white respondents 44% (n=28) and coloured respondents (25%, n=8). A small percentage (3%) said they did not know.

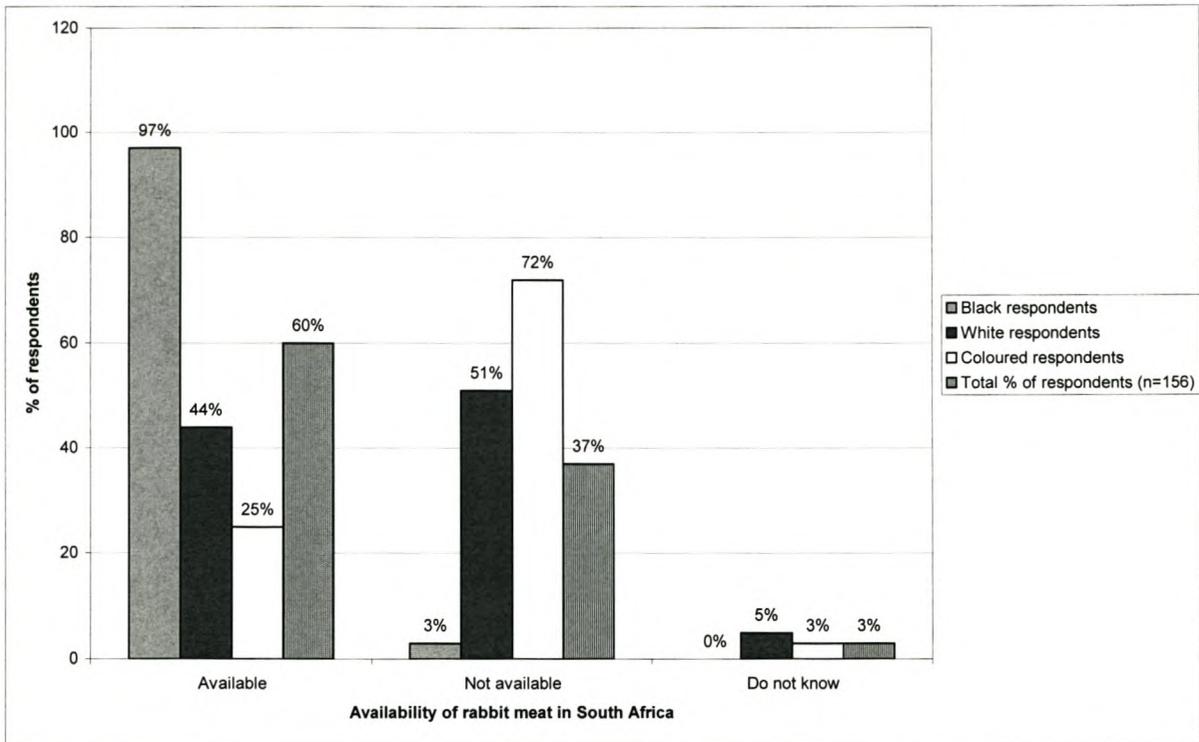


TABLE 17 PERCENTAGES SHOWING THE DIFFERENCES BETWEEN ETHNIC GROUPS ON THE AVAILABILITY OF RABBIT MEAT IN SOUTH AFRICA (n=156)

Figure 18 presents the results in which respondents were asked to rate the availability of rabbit meat in retail outlets, other sales points or as a result of hunting, using a line scale beginning with 1 (not available) up to a value of 9 (to a large extent). Generally, respondents felt that there is no such meat in supermarkets, restaurants or butcheries in South Africa. An opposite tendency occurred in the case of hunting. Most respondents (25%, n=75) felt rabbits could be obtained from hunting (Figure 18). This number was mostly represented by the black respondents (18%, n=54). These findings are supported by the research of Lamar (1998).

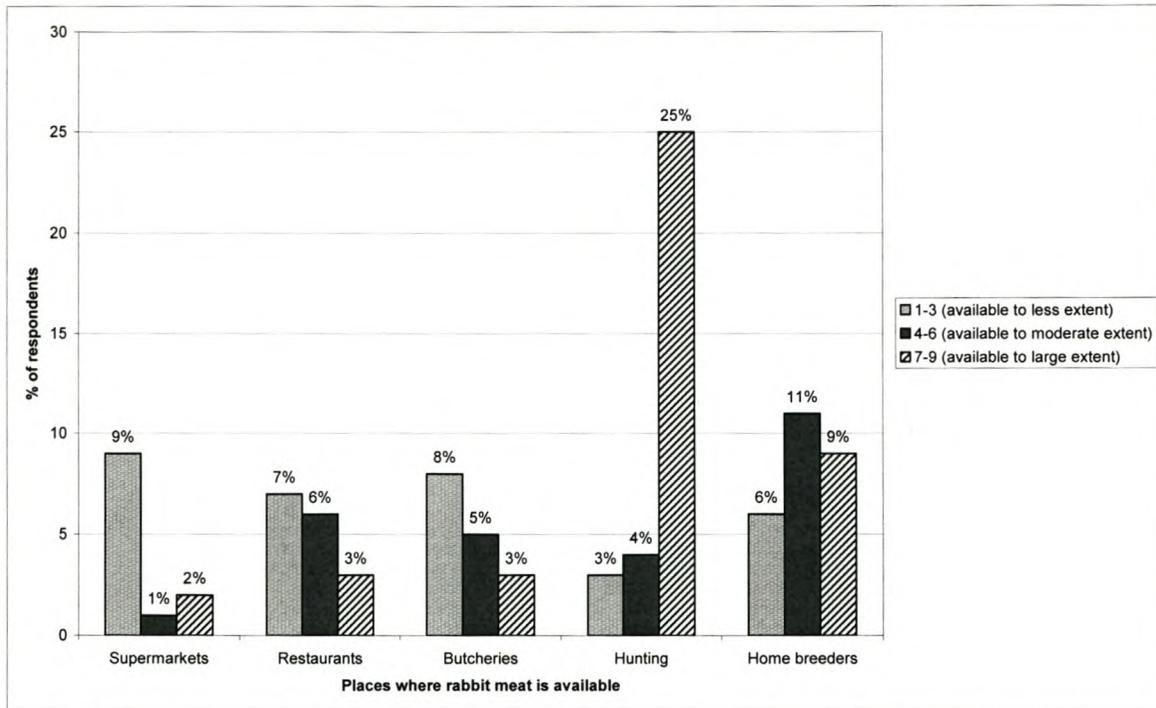


FIGURE 18 RATING OF AVAILABILITY OF RABBIT MEAT IN DIFFERENT PLACES (n=304)

To the question on “*how the seasons affect the availability of rabbit meat*”, approximately 22% (n=67) of respondents were of the opinion that rabbit meat is available in certain times of the year, while 21% (n=64) thought that availability of rabbit meat is not influenced by season of the year (Figure 19 A). Over half of the respondents (55%) did not know.

In this regard the higher percentage for summer (19%, n=57) was followed by the lower percentage for winter (7%, n=20) (Figure 19 B). Sonandi et al. (1996) found that cold weather can contribute to about 3% of pre-weaning mortalities, while heat stress is worse in that about 20% mortalities of mature breeding stock may be the result of heat. Majority of the respondents (73%) did not know.

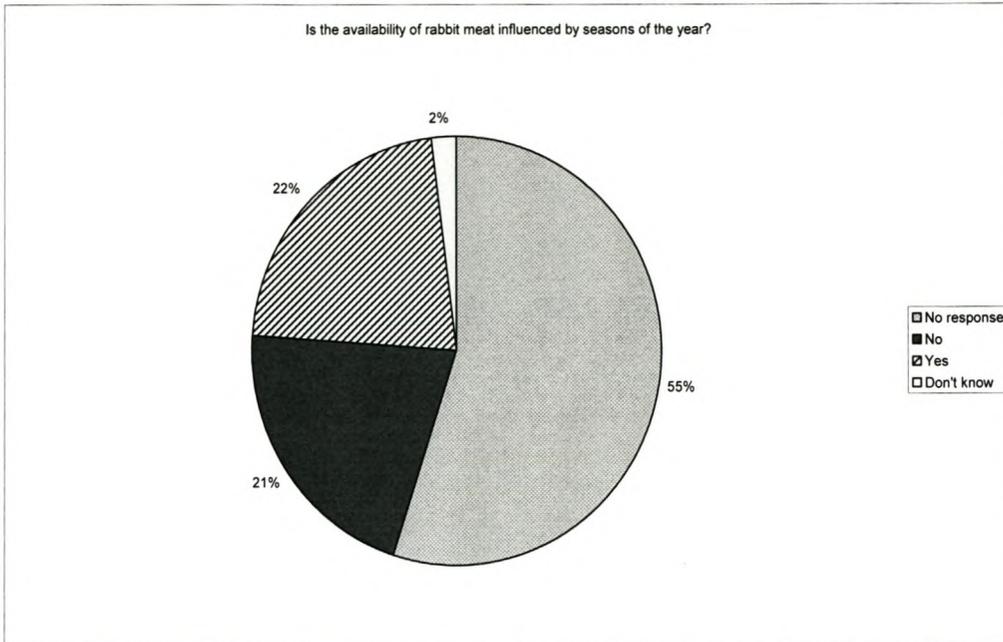


FIGURE 19 (A) AVAILABILITY OF RABBIT MEAT IN CERTAIN TIMES OF THE YEAR

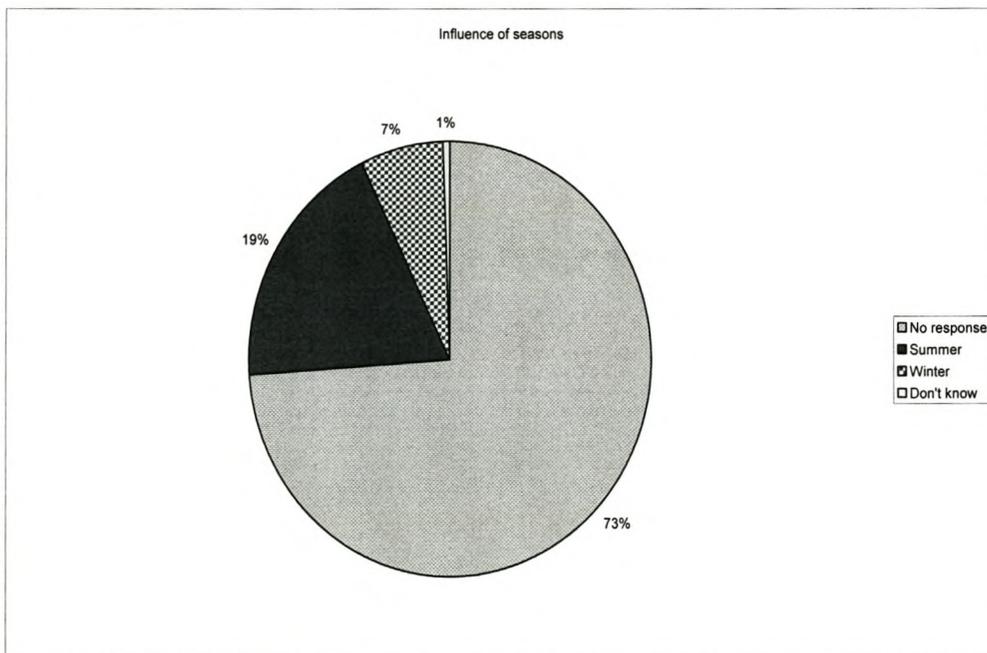


FIGURE 19 (B) AVAILABILITY OF RABBIT MEAT AS INFLUENCED BY SEASONS OF THE YEAR (n=304)

7.4 Conclusions and recommendations

The aim of this study was to investigate the effect of ethnicity on consumer choice of rabbit meat. Based on the information presented in this study it is concluded that the potential demand for rabbit meat in the Western Cape is currently low. There are many major factors contributing to the low potential of consumer choice of rabbit meat. They include associating rabbits with pets, mostly by the white respondents and coloured respondents. The black population (Xhosas) have some cultural beliefs that forbid them to eat rabbit meat, for instance a rabbit is considered a human being by a certain group of Xhosas (the Amavundla group) and thus cannot be eaten. Blacks also associate rabbit with hunting and wild life, so they consider it to be suitable for boys and men and not for women. One other limiting factor for rabbit meat consumption among respondents in this study is availability, which consequently leads to a lack of knowledge about the benefits of rabbit meat in general. From the marketing point of view it is important to note that there are still a large number of respondents who believe that rabbit meat is meat of an unclean animal and very few regard it as healthy meat. In this regard about 52% of the respondents (N=304) have not eaten rabbit meat before, mainly because they have not seen it anywhere and because they never thought about it. However, a certain group of respondents who have not eaten rabbit meat before showed a desire to eat the meat if available, thus the present results suggest a promise to succeed in marketing rabbit meat in South Africa.

In order to increase the consumption of rabbit meat, an effort is needed to educate people regarding the benefits of rabbit meat. This can be achieved by introducing long-term training strategies to familiarise people in the various aspects and multiple benefits of rabbit meat.

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CHAPTER 8

MARKETING FACTORS AFFECTING THE PURCHASING OF RABBIT MEAT: A STUDY IN THE WESTERN CAPE ON ETHNIC GROUPS

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OPSOMMING

Die bemarking van konynvleis het 'n verskuiwing ondergaan, van die verkoop van heel konynkarkasse tot die later ontwikkeling van die verkoop van konynvleis in porsies as 'n geriefsverpakking. Ander bemarkingsvraagstukke met betrekking tot konynvleis, bv. of daar hoegenaamd 'n mark daarvoor is, is ook nie ondersoek nie. In hierdie studie is die bemarkingspotensiaal van konynvleis ondersoek. Die beskrywende opnamemetode, wat gebruik maak van 'n gestruktureerde vraelys, is gebruik en toegepass op 304 respondente. Die gemiddelde waardes van faktore wat die bemarking en aankoop van konynvleis beïnvloed, is bereken. Dit was bepaal dat die mark vir konynvleis nog baie beperk is. Slegs 29% (n=46) van die respondente wat wel konynvleis verbruikers is, het aangedui dat hulle twee keer per maand konynvleis sal wil eet. Meer wit respondente (18%) as swart respondente (11%) en bruin respondente (1%) het in dié kategorie geval. Die resultate gee dui daarop dat respondente, wat verbruikers van konynvleis is, dit sou verkies om konynvleis in porsies (79%), eerder as die hele karkas te koop. Hierdie porsies sal mees bemarkbaar wees as dit as "vars" verkoop word. Die kwaliteit van vleis wat deur al die respondente in hierdie studie, ongeag etniese groep, as mees belangrik beskryf is, is varsheid. Die meeste respondente het aangedui dat hulle die agter- en voorbeen, en borsgedeeltes as porsies sal verkies, met die agterbeen as die mees gewilde gedeelte en die voorbeen as die minste gewild. Die verskille wat waargeneem is in die opinies met betrekking tot die bemarking van heel karkasse, het aangedui dat die swart respondente die kop saam met die karkas sou wou koop. Die hoofrede vir dié voorkeur, is dat hulle wil seker maak dat die karkas wat aan hulle verkoop word, inderdaad dié van 'n konyn, en nie van 'n kat is nie.

Die respondente wat verbruikers van konynvleis is, het aangedui dat hulle sou verkies om die aankoop van konynvleis te beperk tot supermarkte (51%), slagters (47%) en restaurante (36%), eerder as om konynvleis van jagters of telers te verkry. Maksimum verkope van konynvleis kan bereik word deur 'n manipulasie van die verkoopprijs. Resultate het aangedui dat die meeste respondente (60%) sou verkies

om konynvleis teen 'n prys laer as dié van hoender aan te koop, terwyl 37% gewillig sou wees om meer vir konynvleis as vir hoender te betaal. Die verwagtinge en voorkeure van die verskillende respondente met betrekking tot konynvleis is 'n belangrike faktor wat in gedagte gehou moet word by die bemerking daarvan. Die blanke respondente het aangedui dat hulle die vleis van maer, jong (sagte) konyne sal verkies, terwyl die swart respondente aangedui het dat hulle 'n voorkeur sou hê vir vetterige, meer taai konynvleis.

ABSTRACT

The marketing of rabbit meat has experienced a shift from marketing a whole carcass as opposed to later developments of marketing in convenient packaging. Other marketing issues of rabbit meat, e.g. whether there is market at all a, has also not been clarified. This study investigated the potential to market rabbit meat. The descriptive survey method involving a structured questionnaire was used and administered to (n=304) respondents. Amongst these respondents those who consume rabbit meat (n=158) were identified. The mean values of factors affecting marketing and purchasing of rabbit meat were calculated. It was established that the market for rabbit meat was still very low, as only 29% (n=46) would like to eat rabbit meat twice a month. This number consisted of more white respondents (18%) than black respondents (11%) and coloured respondents (1%). Results suggested that respondents eating rabbit meat would prefer buying rabbit meat in portions (79%) as opposed to the whole carcass. These portions would be most marketable if sold "fresh", the most important meat quality required by all consumers regardless of ethnic group. The most preferred portions were back leg, chest and front leg, in descending order. However, the differences observed in the presentation of the carcass indicated that most black respondents would like the head on if they purchased a whole carcass, in order to make sure that it was a rabbit and not a cat.

The respondents who consume rabbit meat would generally prefer to purchase rabbit meat from the supermarket (51%), butcheries (47%) and restaurants (36%), rather than from hunters or domestic breeders. Maximum sales can be achieved through manipulation of price. Results indicated that most respondents (60%) would prefer to purchase rabbit meat at a price less than that of chicken, while 37% are willing to pay more for rabbit meat than for chicken. There was a difference in consumer expectation of rabbit meat, which is critical to know when marketing rabbit meat. In this regard the white respondents demanded lean, young (tender) rabbits, but the black respondents prefer fatty, chewy rabbit meat.

Keywords: Marketing rabbit meat; rabbit meat; purchasing of rabbit meat; retail outlets for rabbit meat

8.1 Introduction

Recent studies indicate that consumer food choices are influenced by health, taste, convenience, visual appeal and reasonable prices (Mermelstein, 2002, Stillings, 1994). The main interest of consumers is to

eat foods that provide far more than the known traditional nutritional benefits in the sense that they tend to view food as medicine, because they are aware that prevention is better than treatment or cure (Mermelstein, 2002, Sloan, 1999). They are therefore very much obsessed with so-called healthy foods, which are perceived to make them feel and look better. These products are characterised by fewer kilojoules, less fat and lower cholesterol (Stillings, 1994).

Sonandi, Masika and Van Averbek (1996) outlined some of the main factors inhibiting the popularity of rabbit meat, which include lack of consumer appeal. They found that a large percentage of consumers of rabbit meat do not like the rabbit carcass to be presented whole as it resembles a cat or a human infant. More recent research by Piles, Blasco and Pla (1999) also recommended a shift from commercialising rabbit as a whole carcass to selling rabbit meat as retail cuts. Presentation of carcass (whole or in portions) influences the slaughter weight. Eady and Prayaga (2000) stated that according to the Australian market demand, rabbits sold as a whole carcass in butcher shops are slaughtered at 1.0-1.3 kg, while those for portions to the restaurant trade are slaughtered at 1.4-1.7 kg. The differences in slaughter weight are associated with differences in growth period on the farm. These new trends towards portioning for the sake of convenience, is accompanied by a change in rabbit meat programmes and involve the increased meat yields and appreciated production traits (Piles et al. 2002). Rabbits to be processed for portions will therefore stay on the farm longer and will thus obtain higher sales prices, but this would involve other economic disadvantages.

The relevance of rabbit meat in the diet and a better understanding of consumer decisions to purchase rabbit meat are of paramount importance due to distinct changes at the consumer level. Successful comprehensive planning and research must take place before a farmer decides to start breeding rabbits in order for commercial rabbit breeding to be profitable (Green, 1999:16). In this regard it is important to remember that marketing of the meat is the most important part when farming with rabbits and it is the most difficult and time consuming. The issues underlying the marketing strategies include the increasing importance of quality, organoleptic and sensory properties of food in general, issues relating to food safety and human health.

Gittens (2000) reported that there is a potential for the marketing of rabbit meat in South Africa, especially in the rural areas as it was already determined in previous studies that the demand is greater than supply. This is confirmed by Billet (1992) who indicated that the rabbit meat industry is promising in the Transvaal (now known as Gauteng). In addition Billy David and Mary Carr, cited by Billet (1992) have a strong feeling that the meat market in Johannesburg is undersupplied. They predict that the demand is likely to grow as the country becomes more cosmopolitan, because there is a niche market for rabbit meat in South Africa among the Caucasian population (French, Portuguese, Italians and other residents of European descent).

Knowledge regarding the marketing factors that affect the purchasing of rabbit meat is scant. Therefore this study was undertaken to establish marketing factors that may affect the consumption of rabbit meat

amongst respondents who consume rabbit meat. Refer to the conceptual framework of the study as indicated in Figure 1.

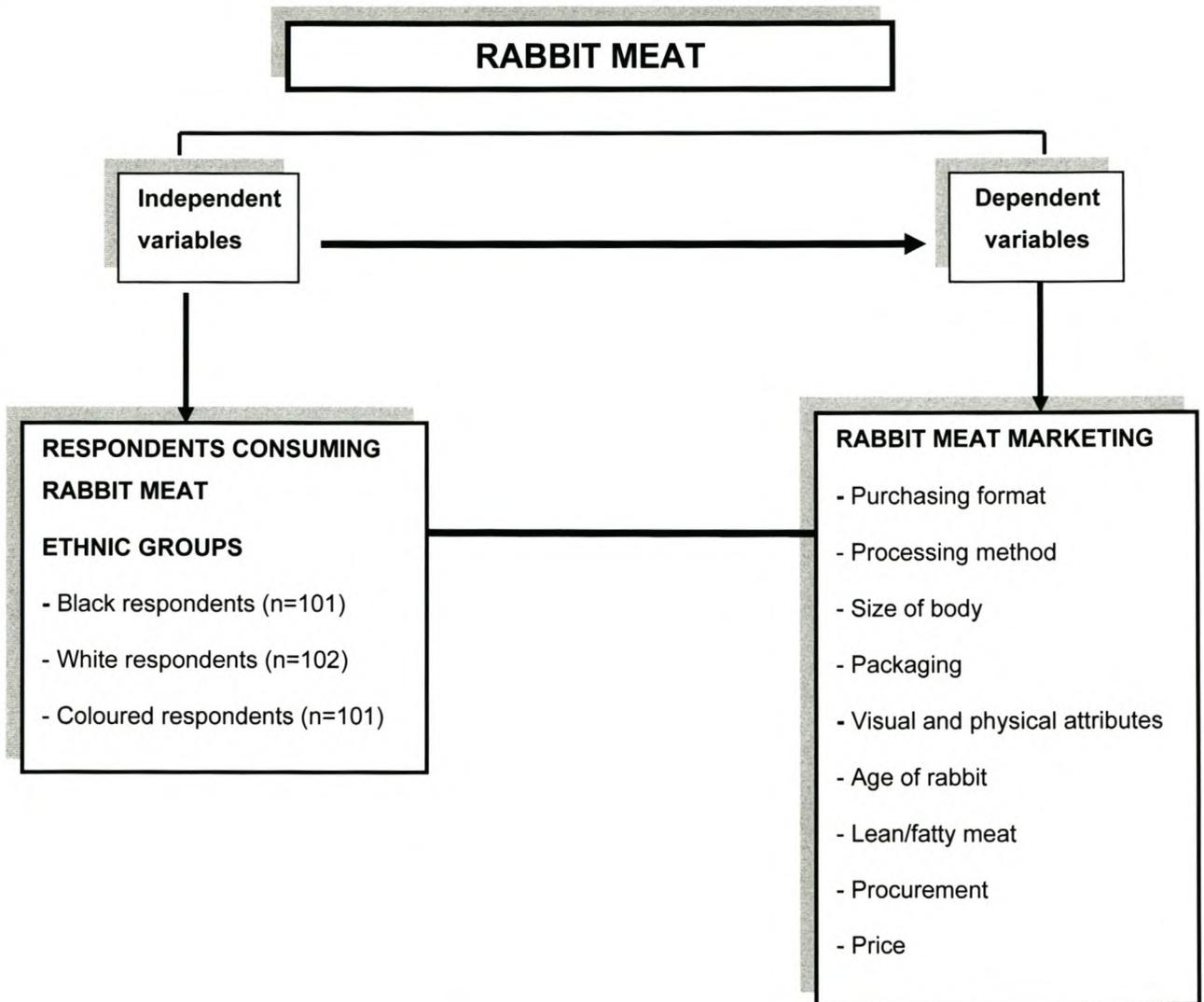


FIGURE 1 CONCEPTUAL FRAMEWORK OF STUDY DEPICTING THE INDEPENDENT AND DEPENDENT VARIABLES

8.2 Methodology

8.2.1 Research design

A quantitative research technique was used because it was considered to be most suited to the aim of the research. The purpose of this survey was to investigate marketing factors affecting the purchasing of rabbit meat in a town in the Western Cape. In order to meet this objective the descriptive survey method

was employed using a structured questionnaire to provide data on the consumer attitude towards rabbit meat.

8.2.2 Study population

The study population consisted of three South African racial groups (black respondents, coloured respondents and white respondents) of different ages and various educational levels. A sample of 304 consumers was randomly drawn from the population residing in the Stellenbosch area and a representation from each ethnic group, namely black respondents (n=101), coloured respondents (n=101) and white respondents (n=102) was used. To achieve a random selection the proportional systematic sampling technique was used (Frankfort-Nachmias & Nachmias, 1996:187). This involved deciding on the number of respondents per ethnic group, and counting residential houses from property layout maps of Stellenbosch area, deciding on the number of respondents required from each area and dividing the number of houses by the sample size decided upon for each ethnic group. A random figure determined the starting point for the systematic sequence to select ethnic respondents. The identified houses were then marked on the area maps and an address list was compiled from the chosen respondents to substantiate the map. Interviews were conducted in Stellenbosch during May-June 2003. The residential areas included were Idas Valley and Cloetesville for the coloured respondents, Kayamandi for black respondents and Uniepark, Mostertsdrift, Dalsig, Universiteitsoord, La Colline, Kromriver, Die Boord, Paradyskloof and Onder-Papegaaiberg for white respondents.

8.2.3 Survey instrument

The survey instrument was designed to examine the effect of ethnic groups (black, coloured, and white respondents) on marketing factors of rabbit meat. The dendrogram technique (Schutte, 1992) analogous to the conceptual framework explained by Frankfort-Nachmias and Nachmias (1996:33) served as a foundation for the design of the survey questionnaire. This technique was applied after the boundaries for the theory were defined during a comprehensive literature review and acted as a guide for asking relevant questions within the scope of study.

The survey instrument was divided into three parts. The first part was to be filled in by all respondents, the second part was meant for those who eat meat, even if they do not eat rabbit meat, while the last part was only for those who had eaten rabbit meat before or who were willing to eat rabbit meat if it was available. This division of the questionnaire in sections resulted in a variation in the total number of respondents per question.

The preliminary questionnaire was evaluated by a panel from the disciplines of Animal and Consumer Sciences. The questionnaire was pre-tested by the researchers in the particular ethnic groups (5 from each group) amongst students on the campus of Stellenbosch University before collection of data commenced. Relevant changes were made on the questionnaire pertaining to these findings.

8.2.4 Data collection and organisation

Three well-experienced fieldworkers were used for the collection of data, after having been screened for suitability as interviewer in the particular area. They were given thorough training to minimise problems that may affect the reliability of the results.

The data obtained from the questionnaire were organised by coding the open-ended questions in order to prepare them for data capturing.

8.2.5 Data analysis

The data were entered into a *Microsoft Excel* spreadsheet. The quantitative data was then subjected to the 8.2 version of the SAS package (1999) for quantifying means, standard deviations, frequencies and percentages. The statistical significance level of differences between the dependent and independent variables were determined by Chi-square tests at $p < 0.05$.

8.3 Results and discussion

According to Nkhabutlane, Hoffman, Schutte and Vosloo (2004) about 47% ($n=142$) respondents in the Western Cape had eaten rabbit meat before at different places (home, restaurant and from hunting). This experience in rabbit meat consumption seemed to contribute positively to the desire to eat it again. They further found that more than half (52%, $n=158$) of the respondents had never eaten rabbit meat before. However, 46% ($n=73$) of these respondents showed the desire to consume rabbit meat if available.

8.3.1 The potential of marketing rabbit meat

In order to establish whether there is a potential market for rabbit meat in the Western Cape, respondents were asked to *indicate the number of times that they would like to be able to eat rabbit meat*. Most respondents (29%, $n=46$) indicated that they would like to have rabbit meat twice a month. This response is not cause for anxiety if the attributes of the Mediterranean diet is kept in mind (Figure 2)

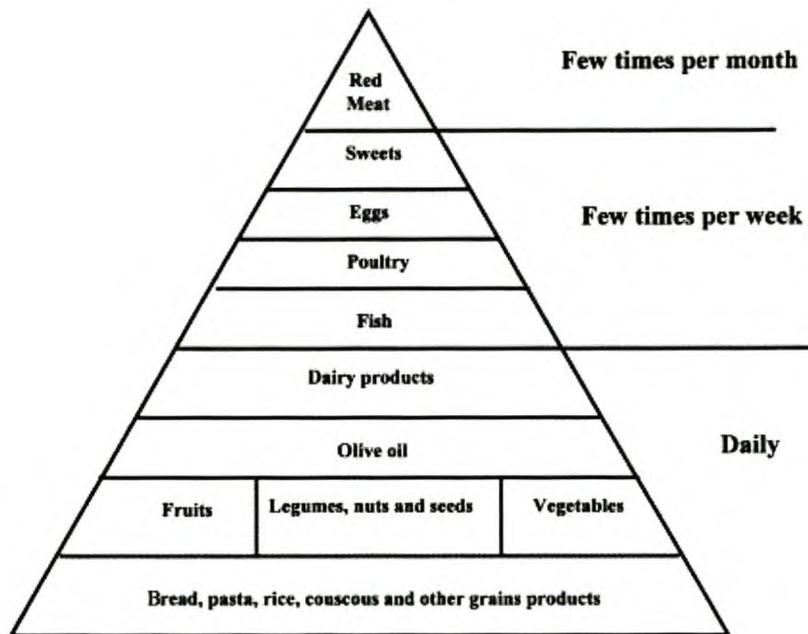


FIGURE 2 THE TRADITIONAL HEALTHY MEDITERRANEAN DIET PYRAMID, ©2000 Oldways Preservation & Exchange Trust (in Goulet, Lamarche, Nadeau and Lemieux, 2003:117)

The marketing of rabbit meat within an understanding of the health-promoting mediterranean diet (Goulet et al., 2003) should be exploited. While the consumption of red meats can only be advocated a few times per *month*, rabbit meat can add to a variety of food stuffs of animal origin that can be consumed a few times per *week* – see the pyramid (The traditional healthy mediterranean diet pyramid, ©2000 Oldways Preservation & Exchange Trust). In the research reported by Goulet et al. (2003:115-124) it was established that there were significant decreases in cholesterol, apolipoprotein as well as body mass index (BMI) after an intervention period of six weeks, with a Mediterranean diet. Marketing strategies should be applied to stress this link between rabbit meat and the mediterranean diet, especially if the positive fatty acid profile (Nkhabutlane, Hoffman, Schutte & Vosloo, 2003) of rabbit meat is also included in the marketing programme.

The ethnic groups differed significantly ($p < 0.01$) with this regard (see Figure 3) to the potential market. The majority of South Africans have a limited intake of meat products and applying diversified marketing strategies for all three income groups would be beneficial.

The black respondents constituted the highest percentage (18%, $n=28$), followed by coloured respondents (11%, $n=17$) and the white respondents with 1% ($n=1$) (Figure 3). These results are in agreement with the statement made by Lamar (1998) that rabbit meat consumption is much easier to develop where people are already used to eating widely different kinds of meat, as from hunting, particularly amongst black

Africans. Asp (1999) also explains the fact that people, who have never been exposed to certain foods, will register a dislike for that particular food.

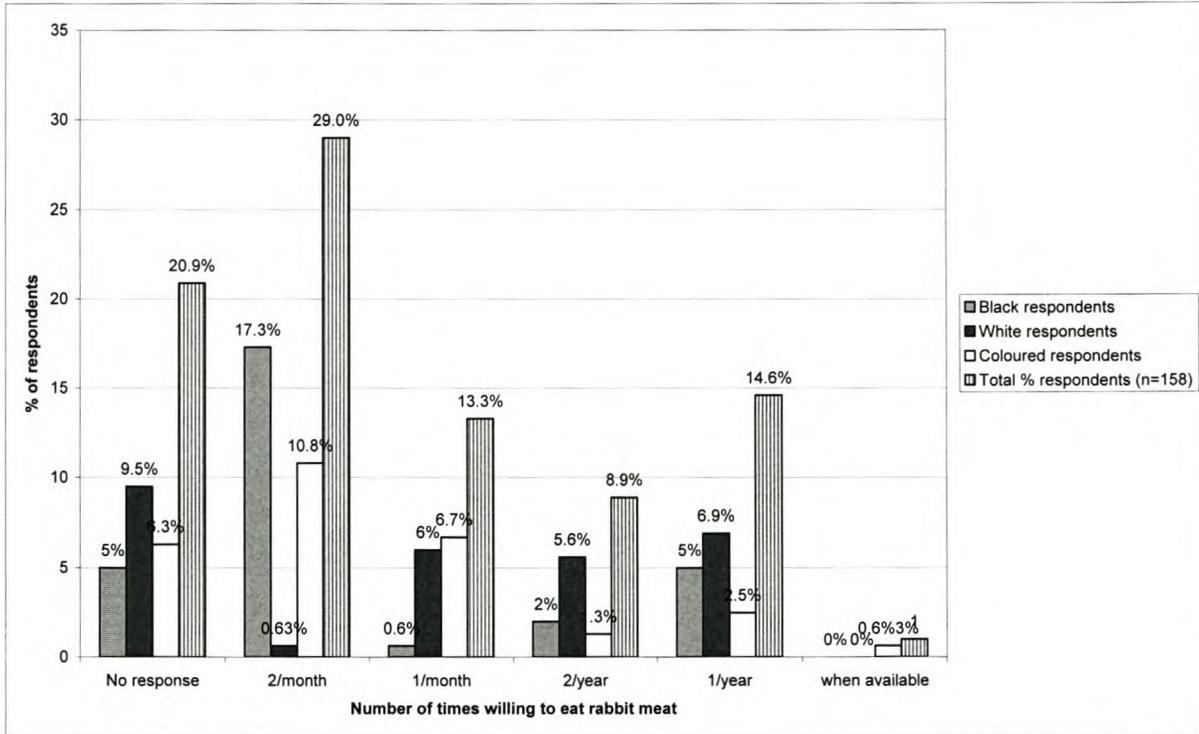


FIGURE 3 THE FREQUENCY IN WHICH CONSUMERS OF RABBIT MEAT WOULD CHOOSE TO EAT RABBIT MEAT (n=158)

8.3.2 Purchasing format of rabbit meat

As indicated in Figure 4, 65% of the respondents who consume rabbit meat would prefer to buy the meat in portions rather than as a whole carcass (20%). The results are in agreement with Sonandi et al. (1996) who found that, in South Africa, a large number of consumers of rabbit meat (79%) do not like rabbit meat to be presented in a whole carcass, as it resembles a cat or a human infant. This may be attributed to the fact that although rabbit used to be commercialised as a whole carcass, a trend of selling rabbit in retail cuts is developing (Piles et al. 1999). Today, convenience is of paramount importance as products that are considered taking too long to prepare will not easily be accepted by the time-pressed consumers (Allen, 1995). Consumers continue to seek simplicity in their lives (Sloan, 2002), and portioning rabbit meat is an important step towards convenience.

Differences regarding the preference for the purchasing format between respondents from different ethnic groups who consume rabbit meat were found (Figure 4).

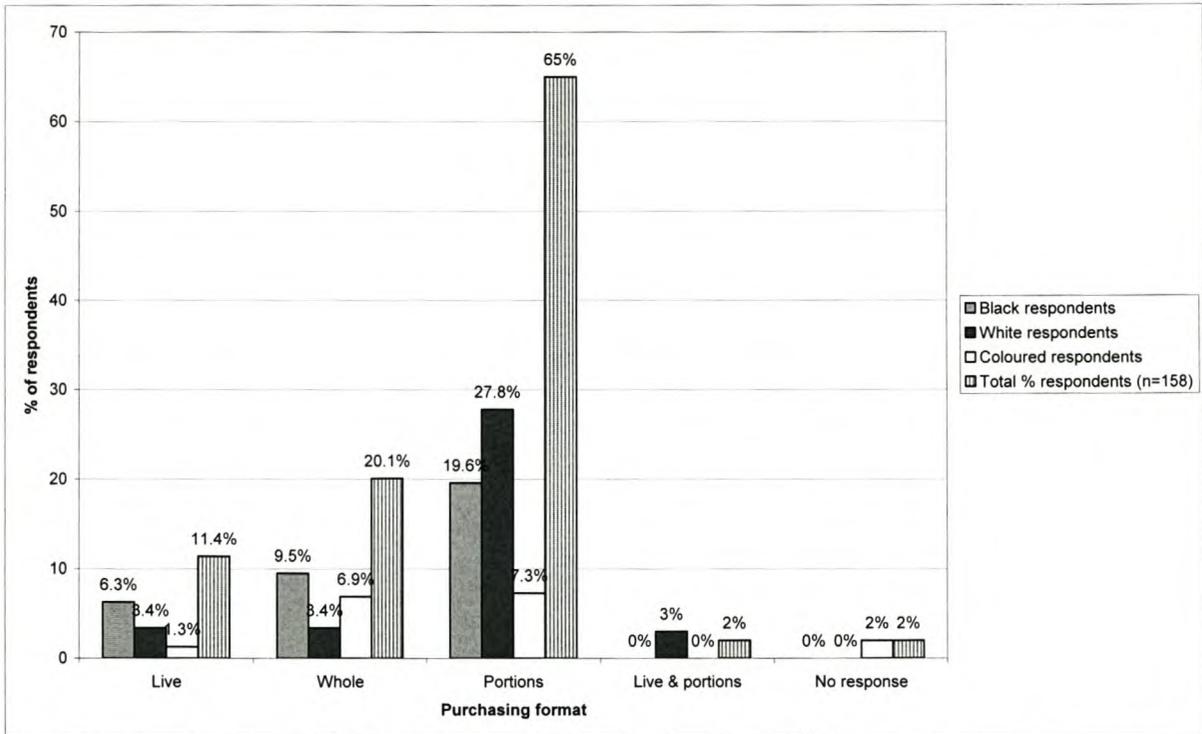


FIGURE 4 THE PREFERENCE FOR THE PURCHASING FORMAT OF RABBIT MEAT PER ETHNIC GROUP (n=158)

Purchasing rabbit meat in portions was preferred by all ethnic groups, but more so by white respondents (28%, n=44) than black respondents (20%, n=31) and coloured respondents (17%, n=28). The preference for buying rabbit meat in portions by white respondents who had a higher household income (Nkhabutlane et al., 2004) was expected whites had a portion packaging provides convenience for housewives and helps consumers to cope with the busy life styles of today (Dalle Zotte, 2002). The other reason for the popularity of the rabbit portions in the package is the fact that it adds more profit per portion than the whole carcass. Dalle Zotte (2002) noted that the trend for selling rabbit meat in cuts or pre-cooked is increasing and this consequently increases the price, but consumers do not hesitate to pay higher prices due to convenience. It therefore becomes very important to identify the specific cuts of a rabbit carcass that are most preferred by consumers. In this regard respondents were asked to rate their preferences for the different cuts of rabbit meat on a nine point scale from prefer less (1) to prefer most (9). The results revealed that preference for rabbit legs was rated the highest (18%), followed by the chest (15%) and the front legs (14%) (Figure 5).

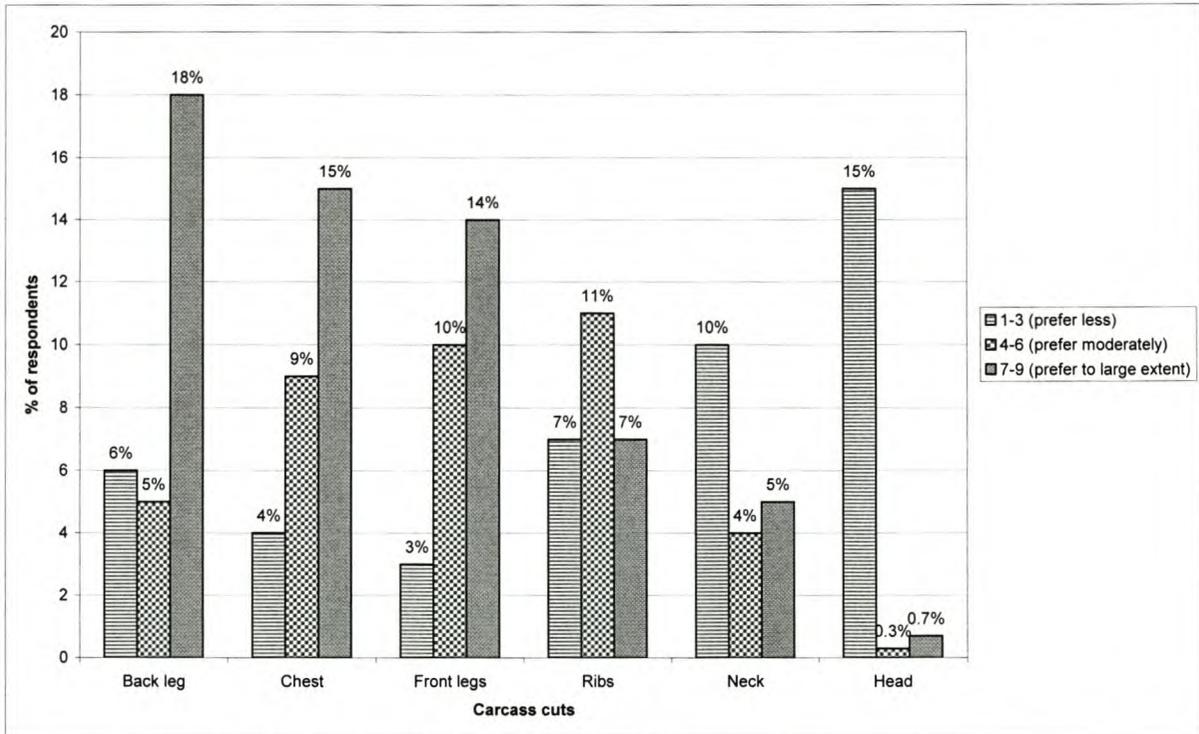


FIGURE 5 PREFERENCE OF RABBIT CARCASS CUTS (n=158)

8.3.3 Processing method of rabbit meat

Results (Figure 6) revealed that the respondents who consume rabbit meat prefer to purchase fresh meat (68%, n=107), over frozen or canned. A significant difference ($p < 0.01$) was observed between ethnic groups regarding this issue. Fresh rabbit meat was preferred more by white respondents (28%, n=44), while similar values were obtained from the black respondents and coloured respondents, respectively 20% (n=32) and 20% (n=31). They argued that fresh meat is healthy. In addition to that, they said the taste, texture and flavour are at their best whilst fresh. This is the reason why most of the stores should give preference to fresh rabbit meat over frozen. This entails having to deliver the meat as quickly as possible after preparation and packaging, since the stores rely heavily upon the ability to display the fresh product in the meat cases for a number of days.

The next group of respondents (25%, n=40) indicated that they prefer frozen rabbit meat. In this regard black respondents preferred frozen meat more (13%, n=21) than white respondents (9%, n=14) or coloured respondents (3%, n=5). Meat retailers are likely to be aware that fresh rabbits under refrigeration have an approximate shelf life of six days, and that rabbit meat not on display will be frozen and thawed as needed (Sandford, 1986, Lamar, 1998). A variety of reasons for this preference was mentioned, which included the fact that respondents are used to buying frozen chicken so they feel rabbit meat should also

be presented frozen just like chicken. They said when frozen, it does not immediately give the impression that it was slaughtered. These consumers also indicated that they do not like the fresh flavour of meat, so they believe that flavour will improve with storage. Sandford (1986) documented that freezing dries out the meat and causes it to lose some of its flavour. To overcome this condition the rabbit meat pieces should be arranged in special packaging material and sealed before being frozen. There was yet another group of respondents (4%) who consume rabbit meat who indicated that, due to the convenience and evident storage advantage of canned meat, they would definitely prefer that option.

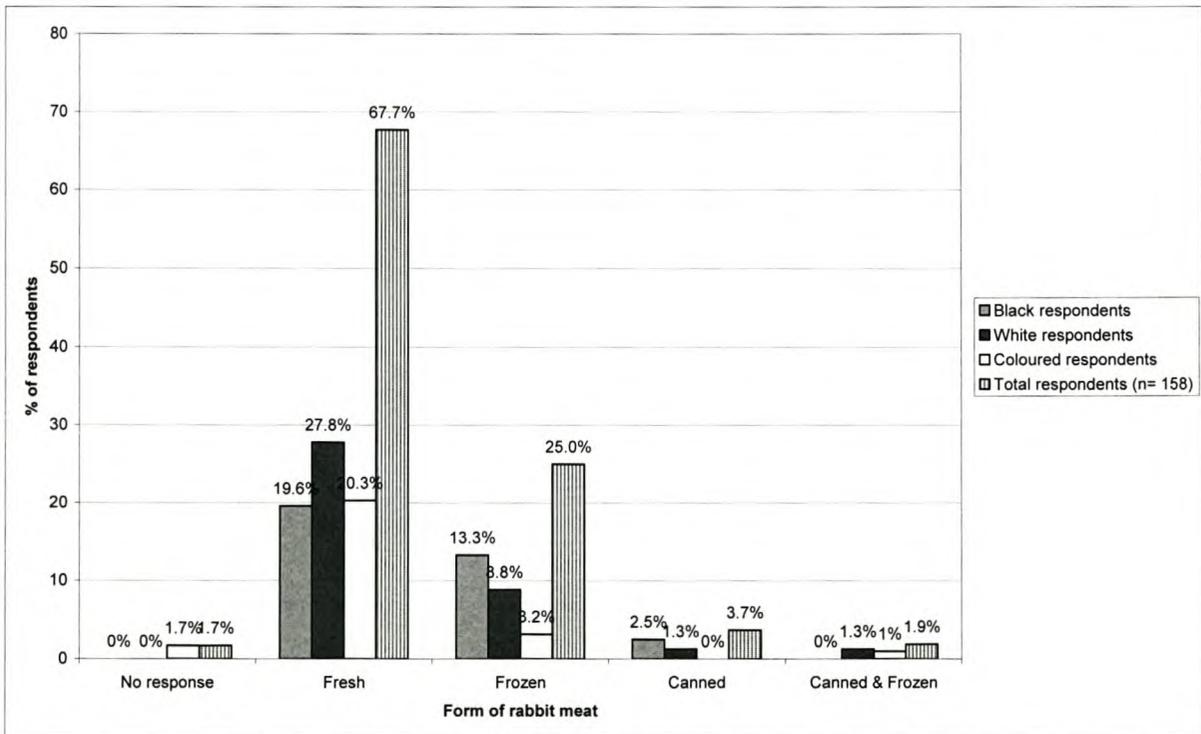


FIGURE 6 PREFERENCE FOR METHOD OF PROCESSING (n=158)

Results showed that if a rabbit is presented as a whole carcass, 56% of the respondents that consume rabbit meat (n=89) would prefer the carcass without head (Figure 7). There was a significant difference between the three ethnic groups ($p < 0.01$) regarding this issue, in that there were more white respondents (29%, n=46) and coloured respondents (14%, n=22) than black respondents (13%, n=21) who indicated that they do not eat the head. Some of the respondents (23%, n=36) indicated that they would only buy a rabbit carcass with the head attached to ensure that it was indeed a rabbit. Many more black respondents stipulated this criterion (20%, n=32) versus white respondents (1%) and coloured respondents (2%). A number of respondents (21%, n=33) did not know.

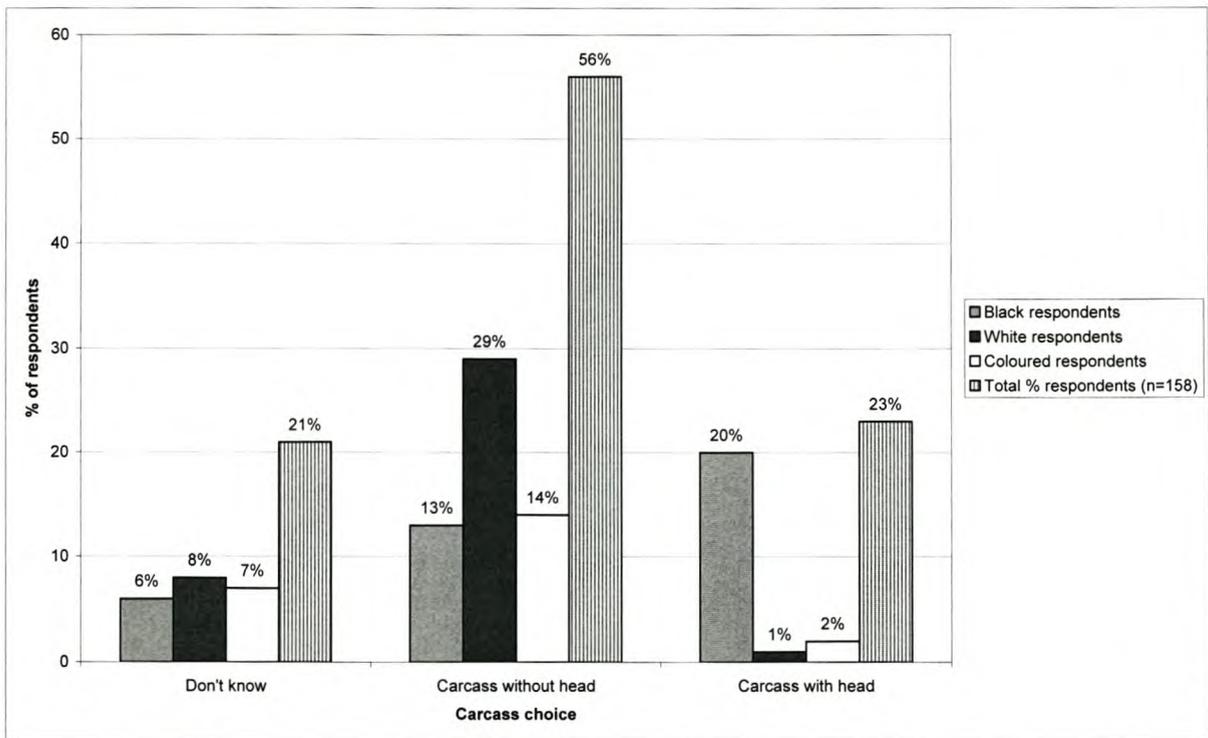


FIGURE 7 INFLUENCE OF ETHNIC GROUPING ON THE CHOICE OF RABBIT CARCASS (n=158)

8.3.4 Size of body

Another factor which may influence the respondents' choice of consumers of rabbit meat could be the size of the body of the rabbit. Considering the fact that the size is a factor of rabbit breed, it is therefore important to note the characteristics of different breeds. The body of the California rabbit is of medium length with well-developed shoulders and hindquarters (Arrington & Kelly, 1976). Medium breeds are recommended for meat production because they are more economical than the large breeds, that are required to be fed more, but do not produce much more meat (Seymon, 1992). Hence a commercial producer should consider table rabbits that are likely to weigh 2 kg at an age of nine to ten weeks, and that will produce the greatest amount of profit.

There was a significant difference ($p < 0.01$) between the ethnic groups concerning the type of rabbit body that they prefer. Slightly more respondents who consume rabbit meat would buy a rabbit with a short body (39%, n=62). Black respondents were presented by a higher percentage (26%, n=41) than white respondents (8%, n=13) or coloured respondents (5%, n=8) (Figure 8). The reasons given for the choice were that rabbits with short bodies are more tender and they have an attractive appearance. These findings are well-supported in literature which encourages producers who aim at producing whole carcasses for marketing in butcheries or in supermarkets, to consider using breeds with short backs in

order to improve the appearance of the carcass. These rabbits include the New Zealand White, California and German breeds.

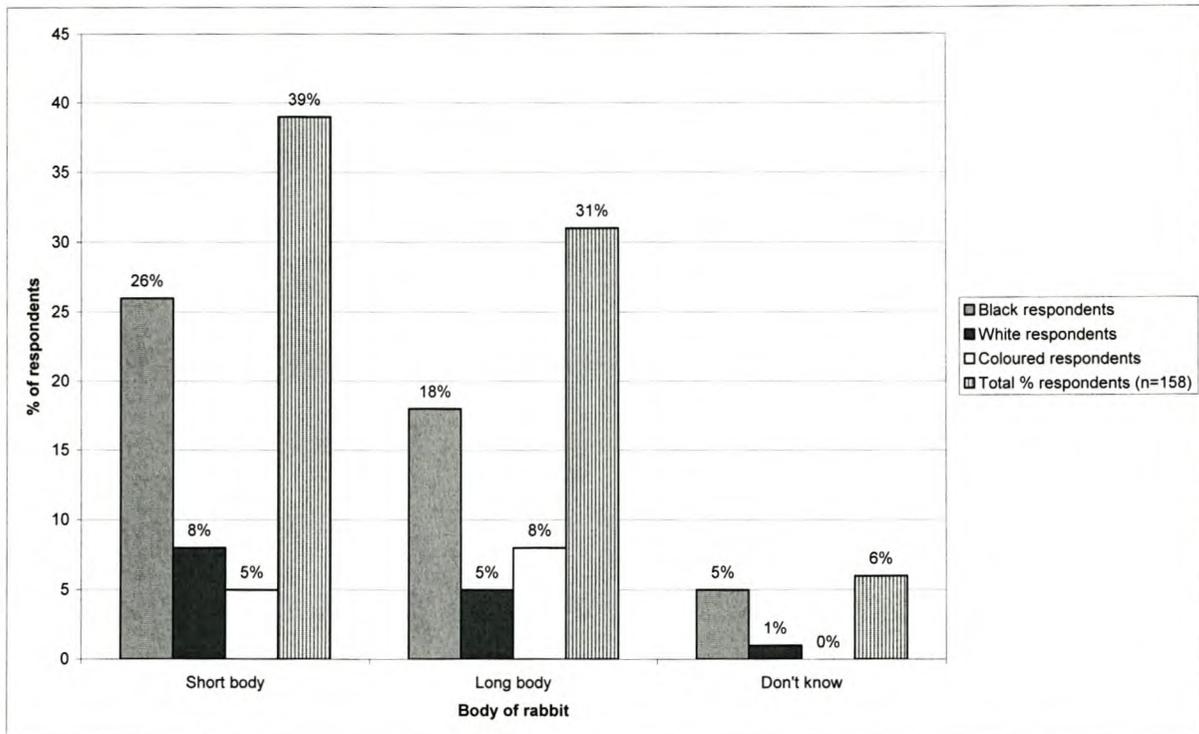


FIGURE 8 EFFECT OF SIZE OF BODY ON THE CHOICE OF RABBIT CARCASS (n=158)

Twenty nine percent (n=31) of the respondents who consume rabbit meat indicated that they would choose a rabbit carcass with a long body, because they believe that it has more meat. This might be partly true, because Arrington and Kelly (1976) said those producing rabbit meat for pre-packed portions are advised to go for breeds with longer backs and a slender short front section as they produce higher yields of the valuable pieces. These include Giants and the Belgian hare. According to Green (1999), there is little difference between the two breeds so the choice depends entirely on personal preference.

8.3.5 Packaging of rabbit meat

The respondents were asked to specify if they would pay special attention to packaging of rabbit meat. The results (Figure 9) indicated that 48% (n=75) may not pay special attention to the packaging while purchasing rabbit meat, while 51% (n=81) would. Although the difference for all 'yes' and 'no' responses was not much, a highly significant difference was observed between gender ($p < 0.02$) and between ethnic groups ($p < 0.01$) regarding this issue. More female respondents (35%, n=56) would pay special attention

to the packaging of rabbit meat than their male counterparts (16%, n=25). The same applied for white respondents (25%, n=39) compared to the black respondents (13%, n=20), and the coloured respondents (13%, n=20).

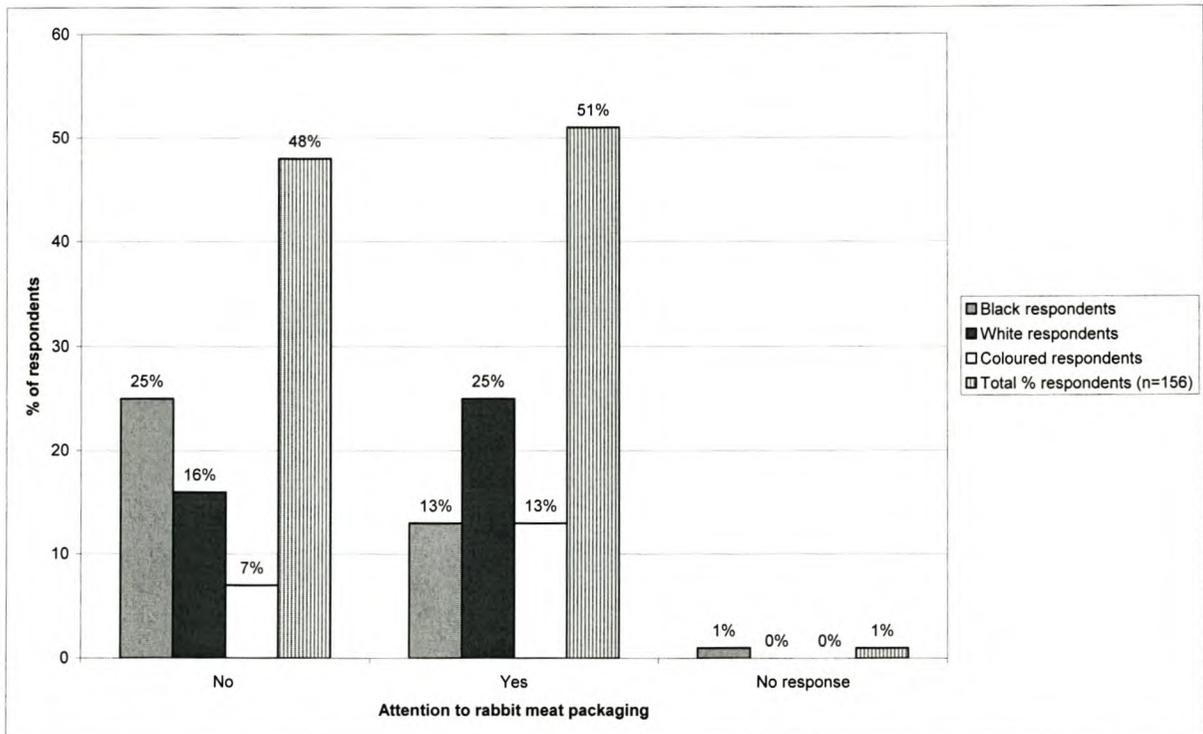


FIGURE 9 ATTENTION TO PACKAGING OF RABBIT MEAT FOR THE ETHNIC GROUPS (n=158)

Respondents were asked to state the *reasons* why they think packaging is important in the marketing of rabbit meat. In response to this question they pointed out that packaging should allow them to see what the meat looks like (12%, n=19). They further suggested that meat in packages will look more attractive if it is in portions of four and arranged similar to chicken (12%, n=19). Packaging should reflect cleanliness and hygiene (8%, n=12), and display the colour of meat (1%, n=3). Six percent of the respondents (n=9) prefer the meat to be vacuum packed, with the sell-by-date, weight of meat and date of packaging indicated on the packaging material, a requirement of the present draft legislation pertaining to the labelling and marketing of food stuffs (Dept of Health, 2002).

8.3.6 Visual and physical attributes

Respondents were asked to “rate the visual and physical attributes according to extent at which they would consider when purchasing rabbit meat”. This is because like all other livestock, rabbit meat products are also evaluated in terms of meat quality and carcass quality (Dalle Zotte, 2002). In this regard characteristics of a product according to consumer's expectations will determine the sale of the product (Warriss, 2000), enabling producers to produce a carcass product that satisfies consumer's specification regarding economic objectives, such as saleable meat yield and attractiveness to the consumer (Dalle Zotte, 2002, Warriss, 2000).

Colour: The results indicated a significant difference between ethnic groups ($p < 0.05$) when considering colour as an important meat quality attribute. Figure 10 illustrates that the respondents who consume rabbit meat are predominantly concerned about colour, when they purchase rabbit meat (17%, $n=27$). This value resulted from 10% ($n=16$) white respondents, 4% ($n=6$) coloured respondents and 3% ($n=5$) black respondents. These results are substantiated by Northcutt (1997) that colour of cooked or raw meat is an important characteristic in the choice of meat, because consumers associate it with the product's freshness, and they decide whether or not to buy the product based on their opinion of its attractiveness. According to Warriss (2000) colour is a major determinant of appearance. Appearance is important because it is practically the only criterion the consumer can use to judge the acceptability of most meat at purchase. Forrest et al. (1975) asserts that the colour of meat is the overall first impression seen by the eye.

Shape/Arrangement: The three dimensional appearance was one of the most important attributes according to the rating of the respondents. This attribute is influenced by the number of portions, type of portions, the size of the portions in the package and placement (Ouhayoun, 1998). The number of respondents who consume rabbit meat and who indicated that they, to a large extent (21%, $n=33$) take note of shape and form was significantly higher than the values obtained from respondents who consume rabbit meat and who mind shape and form to a moderate extent (4%, $n=6$) and from those who do not take it into account at all (2%, $n=3$) (Figure 10).

Ethnic groups differ significantly ($p < 0.02$) in the consideration of shape/arrangement when purchasing rabbit meat. The largest percentage (12%, $n=19$) that considers this trait to a large extent came from the white respondents, followed by coloured respondents (6%, $n=9$) and black respondents (4%, $n=6$) - in decreasing order.

Weight: Respondents who consume rabbit meat also regard weight when purchasing rabbit meat to a large extent (18%, $n=28$). This number is significantly higher than those who consider weight to a moderate extent (8%, $n=13$) and those who do not take note of weight at all (5%, $n=8$).

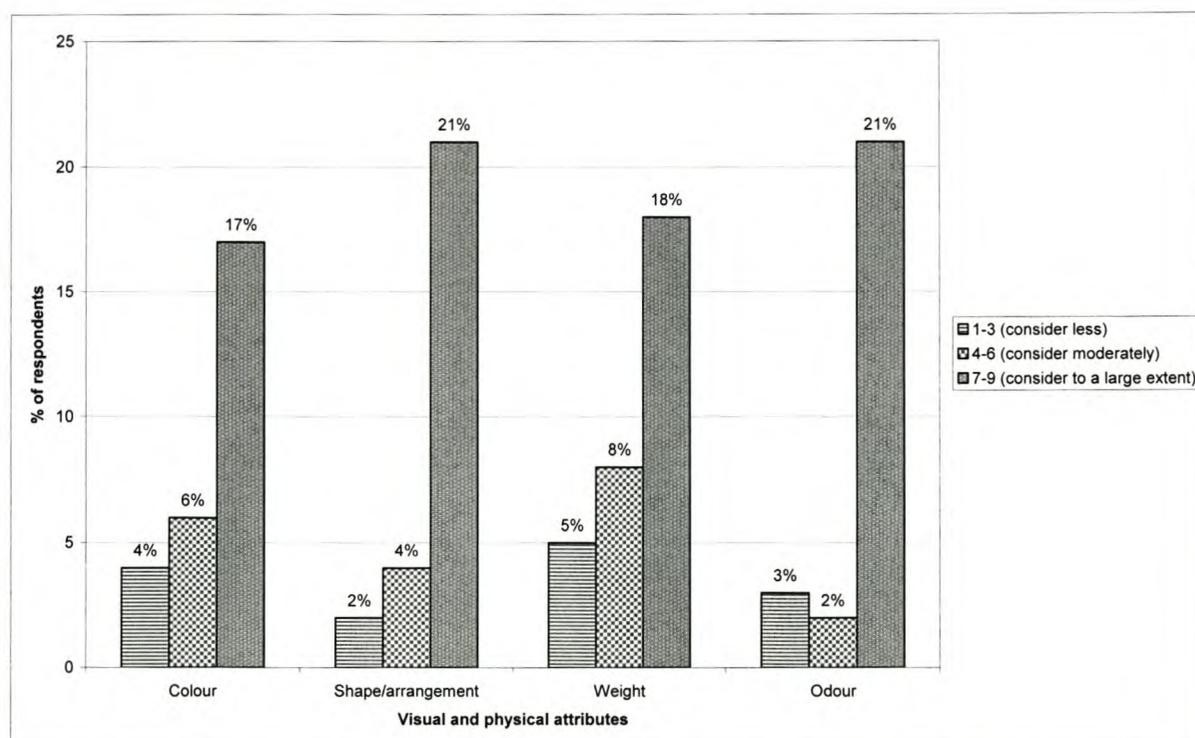


FIGURE 10 THE EXTENT AT WHICH, MEAT QUALITIES ARE CONSIDERED BY RABBIT MEAT CONSUMERS (n=158)

Odour is one of the organoleptic properties which could also influence consumers' decision to purchase rabbit meat. In order to verify this statement, respondents were requested to rate the extent at which they would consider the odour of rabbit meat during purchase. Figure 11 illustrates that a large number of respondents who consume rabbit meat (21%, n=33) would consider odour as an important attribute when purchasing rabbit meat. This value mainly reflected the opinion of white respondents (14%, n=22) which differed significantly ($p < 0.01$) from the coloured respondents (4%, n=6) and black respondents (3%, n=5).

8.3.7 Age of rabbit for meat (old /young)

Rabbit meat is available as fryers, roasters, stewers, and in rare cases, even capons. For the novice grower, an understanding of consumers' choice and reasons for their choice regarding these classifications is essential for a successful rabbit meat business. To obtain information in relation to this type of choice, respondents were asked to indicate whether they would prefer to eat an old or a young rabbit. The results (Figure 11) confirmed the findings reported by Arrington and Kelly (1976) and Lamar (1998) that the greatest demand is for fryer rabbits that are young, tender and meaty. These are rabbits that are not over 12 weeks of age and for some processors they even prefer these fryers not to be over 10 or 11 weeks of age. In this study 58% (n=92) of respondents who consume rabbit meat would prefer a

young rabbit. This number was composed of 29% (n=46) white respondents, 22% (n=35) coloured respondents and 7% (n=11) black respondents (p<0.01). Respondents further gave a variety of reasons for their choice: 38% (n=60) said the meat is more tender while an animal is still young; another 9% (n=14) stated that the meat of a young animal is more tasty and juicier; while some felt young rabbits are healthier than old ones (2%, n=4). It was also interesting to find that some respondents noted that they would choose a young rabbit because it looks more innocent than the old one (2%, n=4).

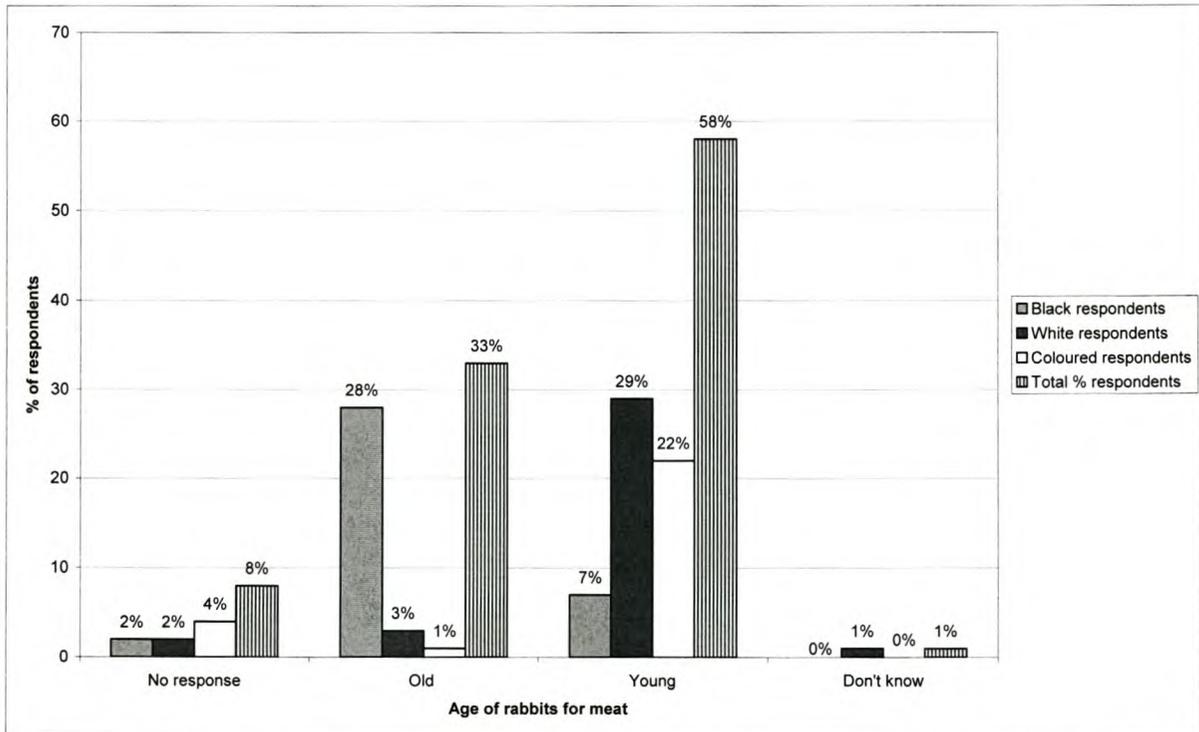


FIGURE 11 PERCENTAGE DISTRIBUTION OF CONSUMER'S PREFERENCE FOR A YOUNG OR OLD RABBIT

Considering these results it is important to note that prices paid for fryer rabbits are higher than for roasters and stewers (Arrington & Kelly, 1976, Lamar, 1998). According to Baldo as quoted by Billet (1992) it is advisable to cull a doe after six to eight matings. At this stage it will be sold for meat and this practice helps to maintain young stock which produces tender meat at a very good price.

The results on the other hand, disclosed that there is yet another group of people that prefer meat of an old animal as opposed to a young one (33%, n=50). They supported their choice with a number of reasons: 19% (n=30) indicated that an old rabbit is chewy, tasty and not sticky. Their opinions are in agreement with Warriss (2000) that the size of muscle fibres increases with increasing age and may be tougher. At 12 weeks of age, the hormones in rabbits start activating. Testicles appear on the bucks, while

the doe's reproductive system begins to blossom. The hormones involved in this process have a direct bearing on the tenderness of the meat - the meat becomes tough (Lamar, 1998). Although many people prefer their meat to be tender it is important to note that many Africans prefer their meat chewy – a fact substantiated by this study. The majority of the respondents (28%, n=46) who preferred meat of an old animal were black (Figure 11).

Another argument in favour of the older animal from some of the respondents (6%, n=10) was that the older the animal becomes the more the meat qualities develop. These results are supported by the findings from Gondret et al. (1998), namely that flavour tends to develop with age, likewise juiciness depends largely on the fat content of the carcass. As age increases there is a marked accumulation of fat in the *m longissimus lumborum* (LL).

Few of the respondents (2%, n=4) associated old with size, so they would go for an old rabbit because of the fact that it has more meat. This view is supported by Warriss (2000) who notes that as animals grow they consequently increase in body weight and height. In addition the proportion of fat in their carcasses increases and the proportion of muscle and bone decreases. One other interesting view from the respondents was that a young rabbit is still breeding so it would be better to eat an old one.

8.3.8 Lean or fatty meat

Considering the fact that the amount of dissectable fat in rabbit carcasses is generally very small (about 3%), it was important to ask South Africans whether they prefer lean or fatty meat. As illustrated in Figure 12, most respondents (68%, n=111) seemed to like lean meat and argued that lean meat is healthy, has a low cholesterol content and that they cannot tolerate fat. A significance difference ($p < 0.01$) between the ethnic groups was observed. More white respondents preferred lean meat (38%, n=63), followed by coloured respondents (18%, n=29) and black respondents (12%, n=19). These results prove that taking advantage of these traits of rabbit meat and putting them in the context of the mediterranean diet, will be of great significance for this particular target market. On the other hand, 32% (n=52) of the respondents would like to have fatty meat and these were predominantly black respondents (25%, n =41). The reasoning behind their choice was that fat improves flavour - they cannot tolerate the lean meat, and to them meat means fat. One other reason was that meat is very expensive, it is therefore much better to eat meat with a lot of fat in order to get a certain satisfaction so as to avoid having to buy more meat after a short while. This comment may have referred to the well-established fact that fat has a high satiety value (Grosvenor, 2000:202). They made it clear that they cannot run from the fact that black people are poor, therefore they need fatty meat because it does not require the addition of other ingredients for flavour.

In order to satisfy the market for black consumers it is therefore important to bear in mind that rabbit meat like all other meats show an increase in intramuscular fat (IMF) content with increase in age, provided the age differences are not too small (Gondret et al., 1998). With this in mind it can be concluded that an increase in intramuscular fat (IMF) content could improve the eating quality of rabbit meat that is low in fat

and generally considered to be insufficiently tasty and juicy. This can be achieved by delaying the age of slaughter, a trait also appreciated by the black respondents who consume rabbit meat.

Studies by Ouhayoun (1998) and Pla, Hernandez and Blasco (1996) prove that large-sized rabbit breeds have a lower fat content than small ones, although the absolute value of these differences is small.

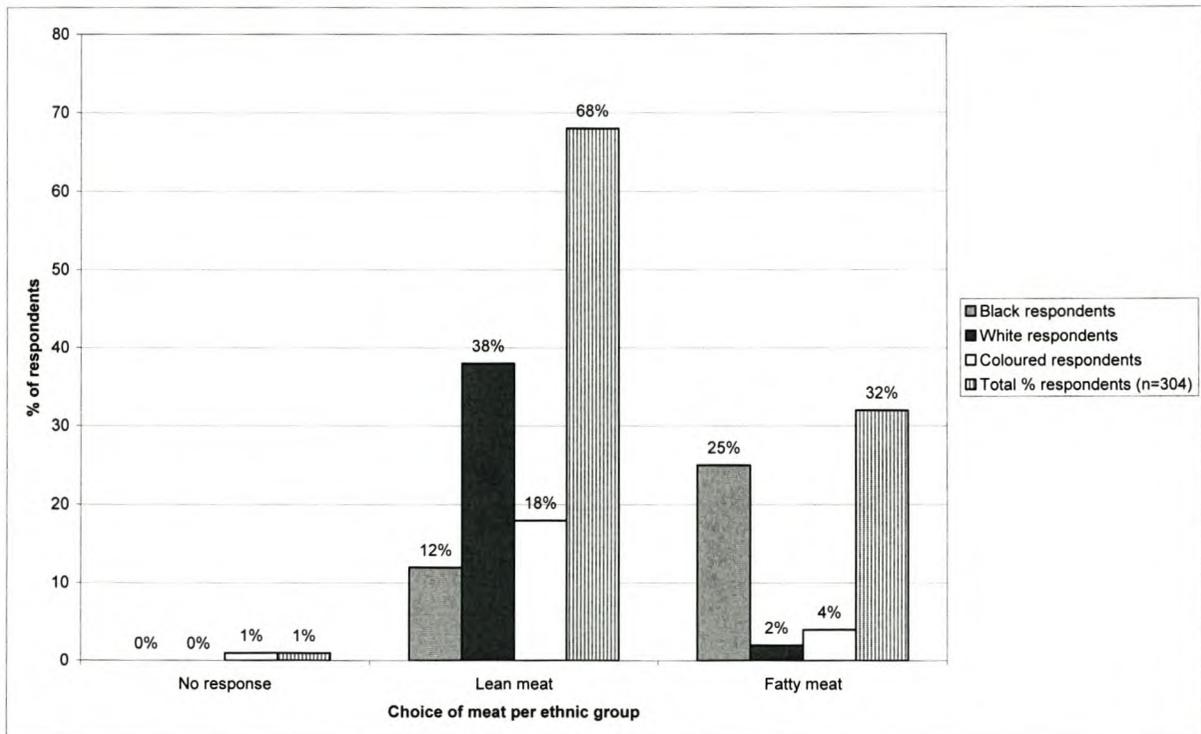


FIGURE 12 PREFERENCE FOR LEAN OR FATTY MEAT PER ETHNIC GROUPS (n=304)

8.3.9 Procurement of rabbit meat

In order to investigate the most suitable places to sell rabbit meat, respondents were asked to indicate with a 'yes' or 'no' to specified places. Significant differences between ethnic groups were clearly demonstrated when respondents expressed their choice to buy or not to buy rabbit meat from various procurements ($p < 0.01$). Generally speaking the results showed that respondents would either buy from supermarkets (29%) or butcheries (30%) (Figure 13 A).

Although the majority of consumers disclosed that they would prefer to buy rabbit meat from the supermarket (30%, $n=89$), this value was a result of a large number of white respondents ($n=51$), black respondents ($n=18$) and coloured respondents ($n=20$). Figure 13 A further elaborates that 18% ($n=56$) of

the respondents were willing to buy rabbit meat from restaurants, this number consisted of 11% (n=36) white respondents, 4% (n=12) coloured respondents and only 3% (n=8) black respondents.

When it comes to procuring rabbit meat from hunters 17% (n=53) of the total respondents indicated that they would buy rabbit meat directly from them. Ethnic groups differed greatly ($p < 0.01$) in this regard. The same number of white respondents and coloured respondents (3%, n=10) would buy rabbit meat from hunters, and black respondents represented a considerably higher value (33%). Only 8% (n=24) would buy meat directly from the rabbit breeders.

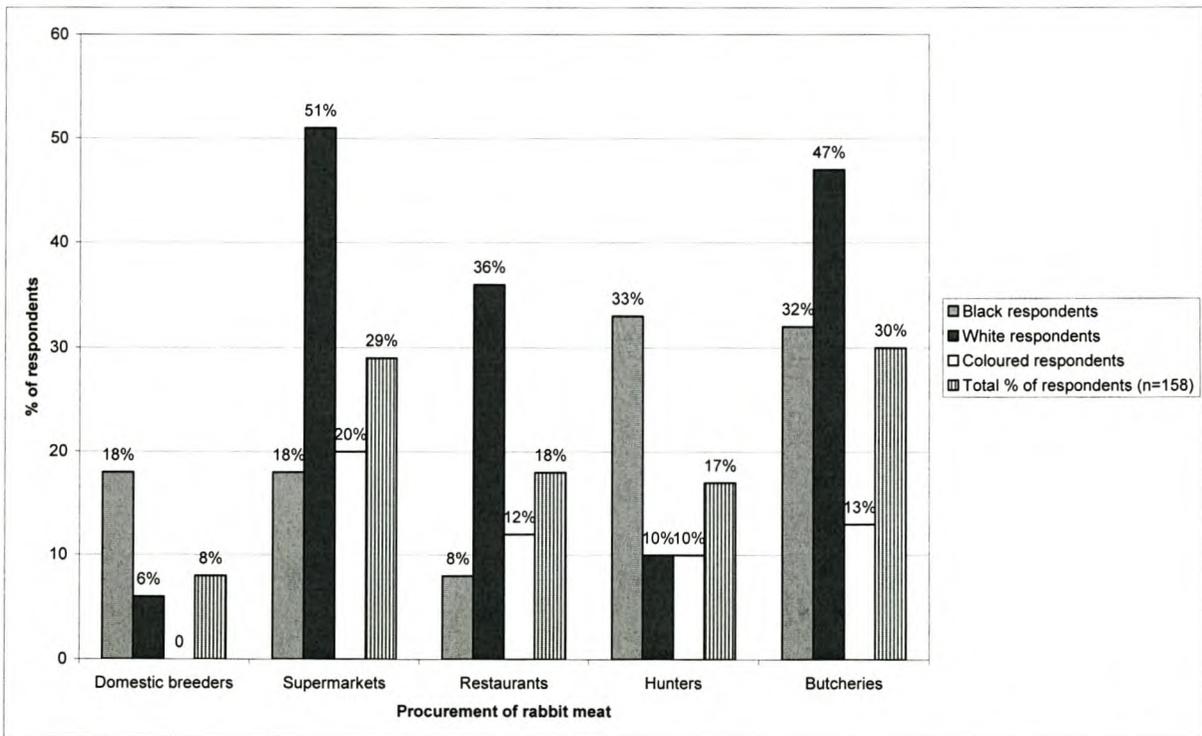


FIGURE 13 A PLACES WHERE RESPONDENTS WOULD LIKE TO BUY RABBIT MEAT (n=158)

The respondents indicated that they would mainly not purchase from domestic breeders (18%). This was particularly so for white respondents (who preferred to purchase in supermarkets, butcheries and restaurants). This pattern also followed for the purchase of rabbit meat from hunters (Figure 13 B).

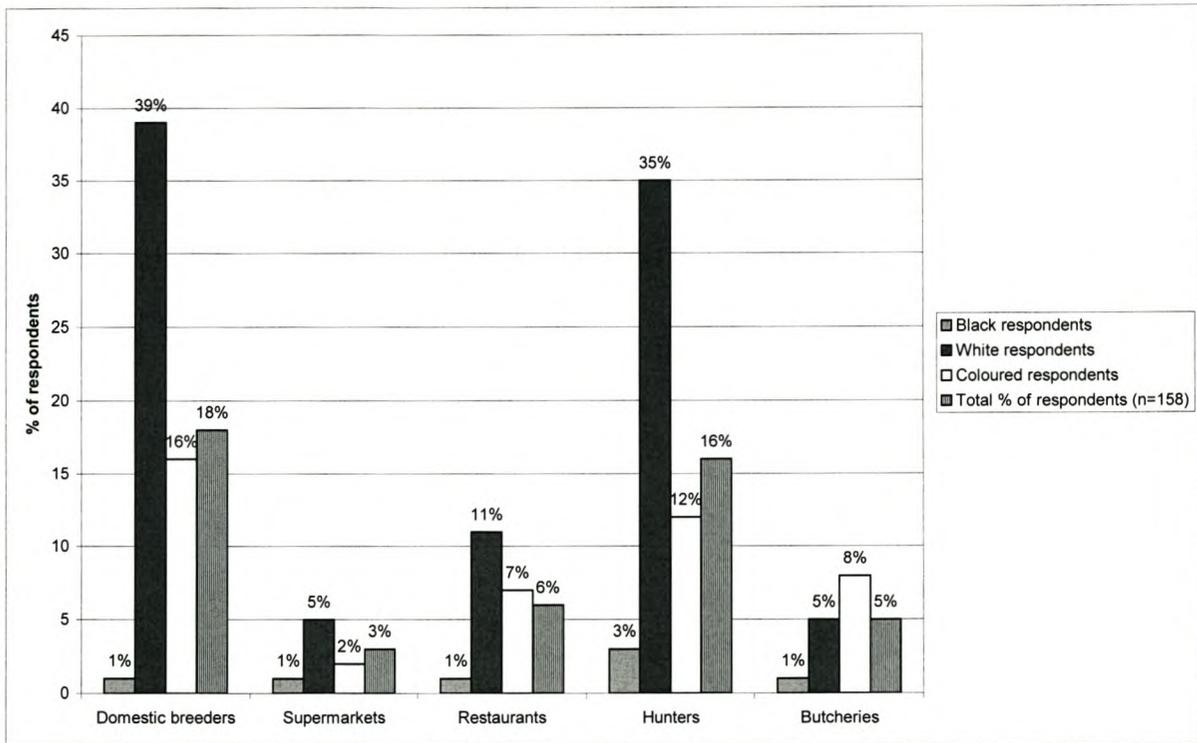


FIGURE 13 B PLACES WHERE RESPONDENTS WOULD NOT LIKE TO BUY RABBIT MEAT (n=158)

8.3.10 Price

Dalle Zotte (2002) argues that the lower production of rabbit meat in developed countries compared to other meat is too prohibitive. The production costs for rabbits are twice as high as for chicken broilers and about 20-30% higher than for pigs. This implies that rabbit meat consequently becomes more expensive than other white meats and thus its consumption is automatically decreased. Respondents were asked to indicate whether price could influence their decision to purchase rabbit meat. The results revealed that a larger number of respondents who consume rabbit meat (57%, n=90) would definitely consider price, whilst only 12% (n=19) indicated that the price would not influence their purchase (Figure 14).

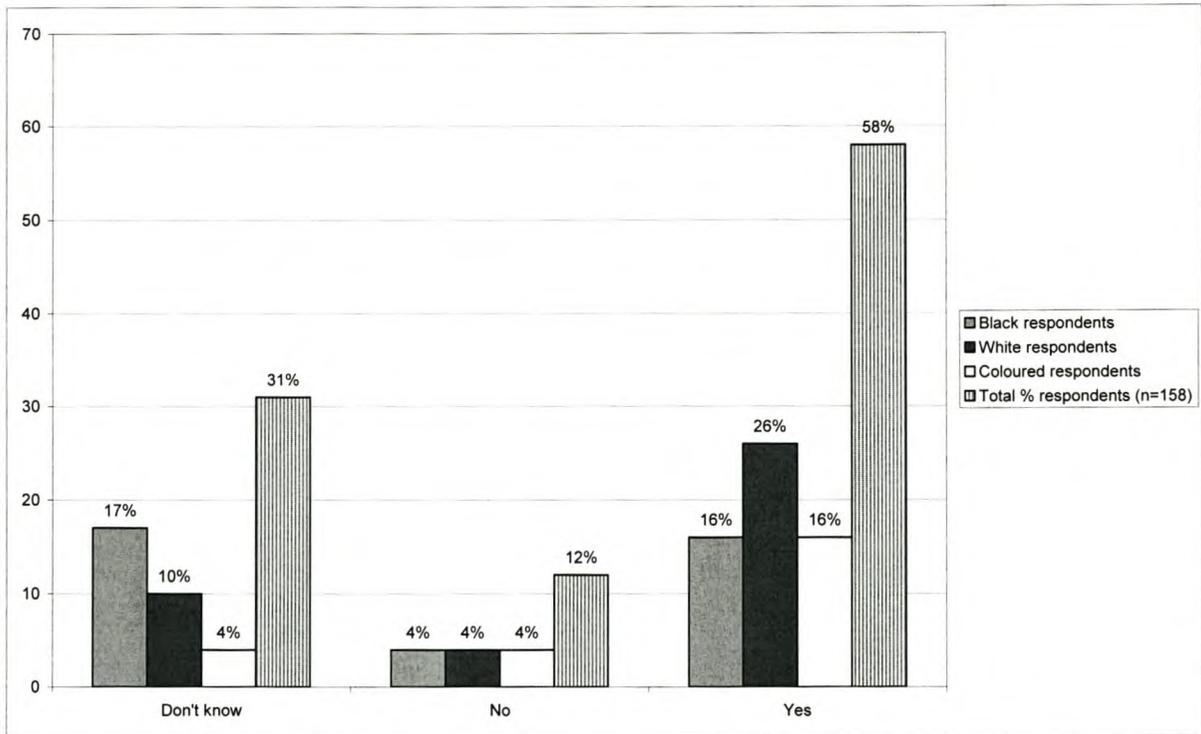


FIGURE 14 THE INFLUENCE OF PRICE ON THE DESIRE TO PURCHASE RABBIT MEAT (n=158)

Respondents were requested to express their opinions on whether they would be prepared to pay more, less or the same price for the rabbit meat compared to chicken. Figure 15 illustrates that about 60% (n=72) of respondents who consume rabbit meat would like to pay a price that is lower than that of chicken, which represented 26% (n=31) white respondents, 18% (n=22) coloured respondents and 17% (n=20) black respondents.

There was a considerably lower percentage (38%, n=45) who would be prepared to pay more for rabbit meat than chicken and 2.5% (n=3) would pay a similar price to chicken. These results were in agreement with Hoffmann et al. (1992) that a higher price for rabbit meat compared to other meat is a limiting factor in the marketing of rabbit meat.

It appeared as if respondents expected that it should be possible to market rabbit at a cheaper price than chicken. The reality however is that when considering the cost of feeding the animals, and the rate of production it would not be possible to market rabbit meat at a cheaper product.

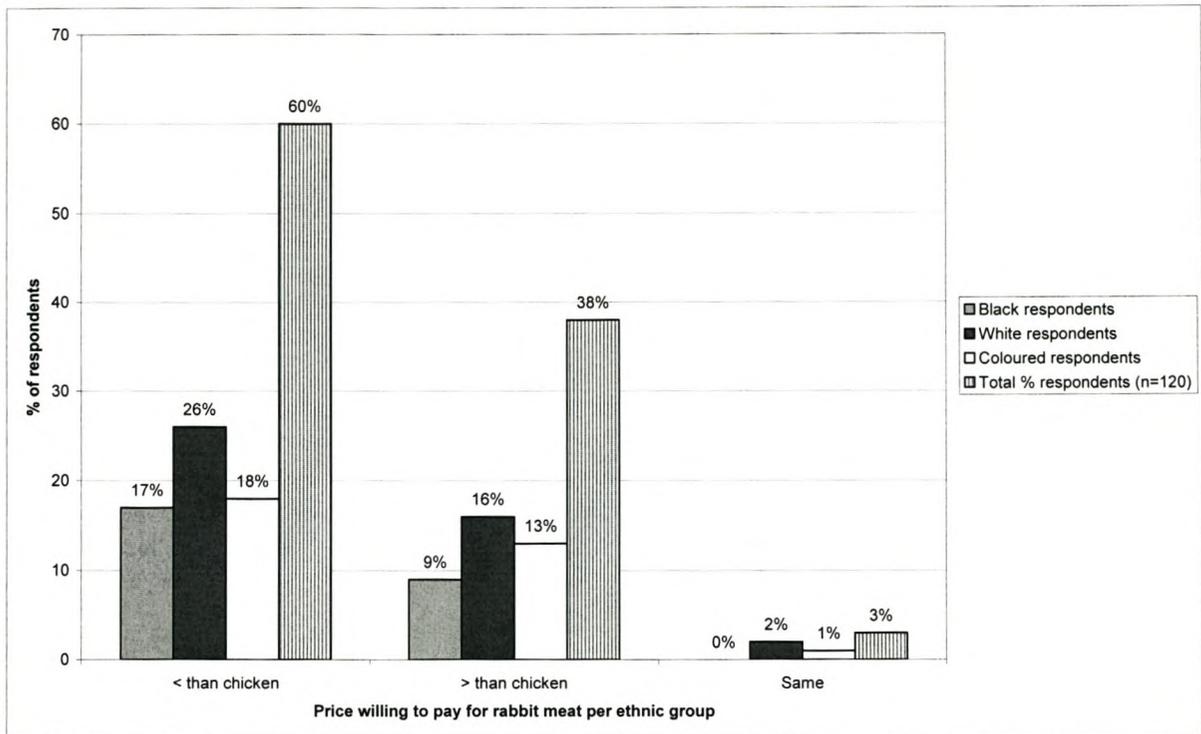


FIGURE 15 INDICATION OF THE PRICE THAT RESPONDENTS WOULD BE WILLING TO PAY FOR RABBIT MEAT (AS COMPARED TO THE PRICE OF CHICKEN) (n=120)

8.3.11 Marketing of offal

McCracken (1994) suggested that, due to the continuous increase in price of red and white meat, offal is the most affordable alternative protein source. However, 83% of the respondents in this study indicated that they would not be willing to eat rabbit offal (Figure 16).

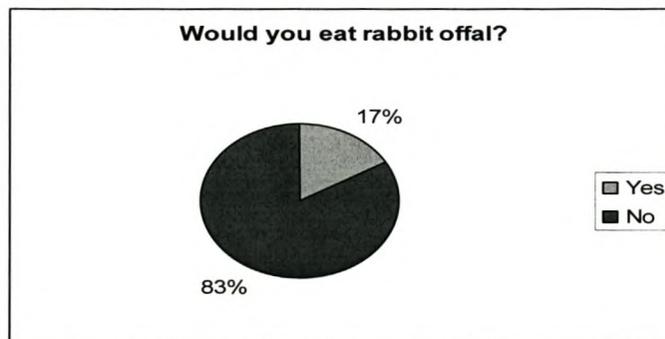


FIGURE 16 WILLINGNESS OF RESPONDENTS TO CONSUME RABBIT OFFAL (n=158)

According to Figure 17, the few respondents who indicated that they would consume rabbit offal, showed that livers were preferred most (21%) followed by the heart of rabbit (13%). The least preferred were lungs (12%) followed by gastrointestinal tract (9%).

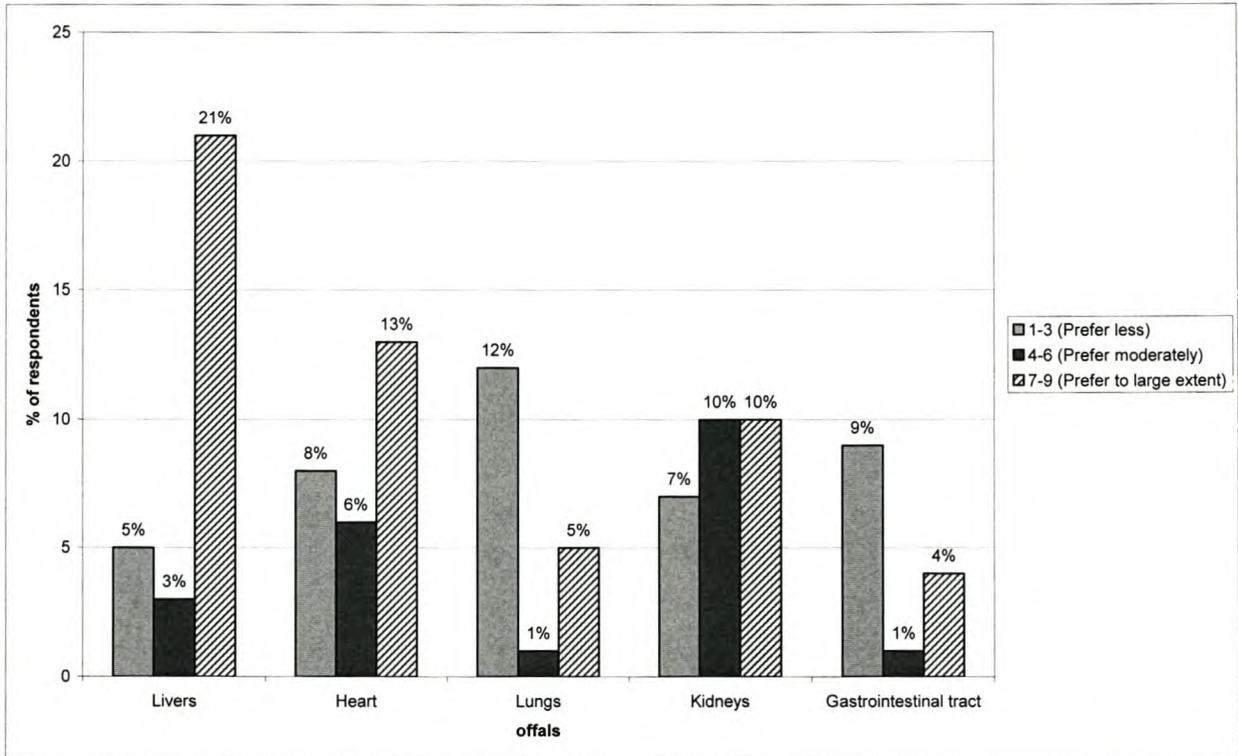


FIGURE 17 THE RATING OF RABBIT OFFAL ACCORDING TO RESPONDENTS PREFERENCE (n=158)

8.4 Conclusions and recommendations

The ethnic groups in this study seemed to differ significantly regarding various factors affecting the marketing of rabbit meat. These include consideration of the form and presentation of rabbit meat for sales. Although the general demand is for cut up portions, white respondents represented the highest proportion for this requirement. It is for this reason that white respondents disclosed that they would not mind to purchase rabbit without head, while black respondents insisted that a rabbit should have a head on, in order to make sure that it is a rabbit and not a cat. Significant differences were also observed on the choice of places to purchase rabbit meat, from which supermarkets, butcheries and restaurants were ranked high by white respondents and coloured respondents while black respondents rated the procurement from hunters and butcheries high. However, the increased demand for fresh rabbit meat

was common to all ethnic groups. A large percentage of consumers of rabbit meat (60%) indicated that they were not willing to pay a price for rabbit meat exceeding the price of chicken. This particular finding is further proof that there is a large shortcoming in the marketing of the positive aspects of rabbit meat that needs to be addressed.

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CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS:

Meat quality attributes.

The possibilities of higher quality meat with high added value are of great interest to the meat-processing sector, considering the fact that consumers are persistently demanding so-called healthy meat. The need to monitor factors determining the quality of meat products would be helpful in order to respond to these demands and to make meat products more consumer friendly.

The present study focussed on meat quality and carcass quality traits of commercial rabbits (California and hybrid = California x Dutch red) as influenced by breed and age at slaughter. In addition, the marketing of rabbit meat as affected by differences in ethnic groups was evaluated in a town in the Western Cape South Africa.

Carcass quality for this study included saleable meat yield (meat obtained from hind leg, fore leg and chest portions), carcass weight (Weight for both hot and chilled carcass), slaughter yield (weight of rabbits before slaughter) retail cuts yield (proportion of hind leg, fore leg and chest to body weight), meat:bone ratio, dressing percentage and chill loss (hot carcass weight – chilled carcass weight).

Although it was not easy to define meat quality as it varies widely according to the individuals to whom it is addressed, for the benefit of this study meat quality included the measurements of physical traits such as pH, temperature and colour, nutritional properties: proximate analysis, minerals, fatty acids, cholesterol and amino acids.

Breed was not a major factor affecting growth performance, feed efficiency and carcass weight. With regard to carcass quality, it was found that breed had an effect on slaughter yield and meat yield. California breed yielded higher dressing percentage and meat yield due to lighter weight of organs observed in this breed.

Age significantly influenced the carcass quality to a large extent ($P < 0.01$). Hot and chilled carcass weight increased greatly with increase in age and, at the same time, higher dressing percentages were noted in more mature animals. Moreover, the proportion of the weight of organs (full gastro-intestinal tract, liver, kidney, and set of trachea, heart and lungs) to carcass weight decreased with age. This gives an implication that the good quality rabbits are those of an older age. The value of these more mature animals was also evidenced by meat yield percentage that was higher in older rabbits than in younger age.

Furthermore the moisture content decreased with an increase in age while fat content increased significantly. The meat of younger rabbits contained more protein than that of older rabbits, but no difference was observed in ash content as a result of age.

The meat quality attributes were affected by breed in that higher fat content was observed in the California breed compared to the hybrid. These differences between muscles in their lipid content were correlated with differences in their moisture content. Significant differences between the two breeds were observed with regard to mineral elements. California breed contained more phosphorus and magnesium than hybrid. However, both breeds had low sodium content. The fatty acid profile of California breed was significantly better than that of hybrid. Nevertheless, the results confirmed that the largest percentage of fatty acids in rabbit meat is from polyunsaturated fatty acids, thus resulting in a desirable PUFA:SFA for human nutrition. Cholesterol content and amino acid profiles were not affected by breed.

From this point of view, delaying animal age at slaughter could probably lead to an improvement in the eating quality of rabbit meat. However, all other factors, which could contribute to the development of muscles and fat during the growing period, need to be studied carefully.

The growth performance for both breeds used was generally slow, and resulted in poor feed conversion ratio of the animals. It is recommended that the animal feed industries produce balanced feed for meat-producing rabbits to speed up the growth rate of rabbits and to reduce the feed conversion ratio.

With regard to meat quality it is recommended that future research focus on determining the effect of age on cholesterol, fatty acids, amino acids and mineral content of rabbit meat. Information on the sensory qualities of rabbit meat would be valuable, especially with regard to differences between rabbits slaughtered at younger and older ages and between breeds (because of the differences in lipid content noted).

CONCLUSIONS AND RECOMMENDATIONS:

Consumer attitudes towards rabbit meat

The investigation on the differences of ethnic groups pertaining to their perceptions and attitudes towards rabbit meat, revealed certain differences in ethnic groups that contribute to the limited popularity of consumption of rabbit meat as the fact that white and coloured respondents associated rabbits with pets. It was also observed that the consumption of rabbit meat by the black population (Xhosas) was dependent on cultural and traditional beliefs, for instance a rabbit is considered a human being by a certain group of Xhosas (the Amavundla group) and thus cannot be eaten. Blacks also associate rabbit with hunting and

wild life, so they considered it to be suitable for boys and men and not for women. Lack of knowledge on the benefits of rabbit meat regarding convenience, sensory qualities and nutritional value of rabbit meat constrained food choice of rabbit meat.

Results obtained in this study are stressing that the demand is for cut up portions as opposed to whole carcass. The cut up portions is a trend resulting from the limited time available for meal preparation by today's consumers. White respondents represented the highest proportion for this requirement. Nevertheless, the rabbit carcass sold in portions gives an advantage to the producer because the sales price increases due to the services involved. Hence, procurement for rabbit meat from supermarkets, butcheries and restaurants were ranked high by white respondents and coloured respondents while black respondents ranked hunters and butcheries high.

Despite the fact that about half the respondents have not eaten rabbit meat before, the envisaged future for marketing rabbit meat in South Africa is promising. This is because those that have eaten it before seem to have a positive attitude towards consumption of rabbit meat, while 57% of those who have not had it before are optimistic in their willingness to eat the meat.

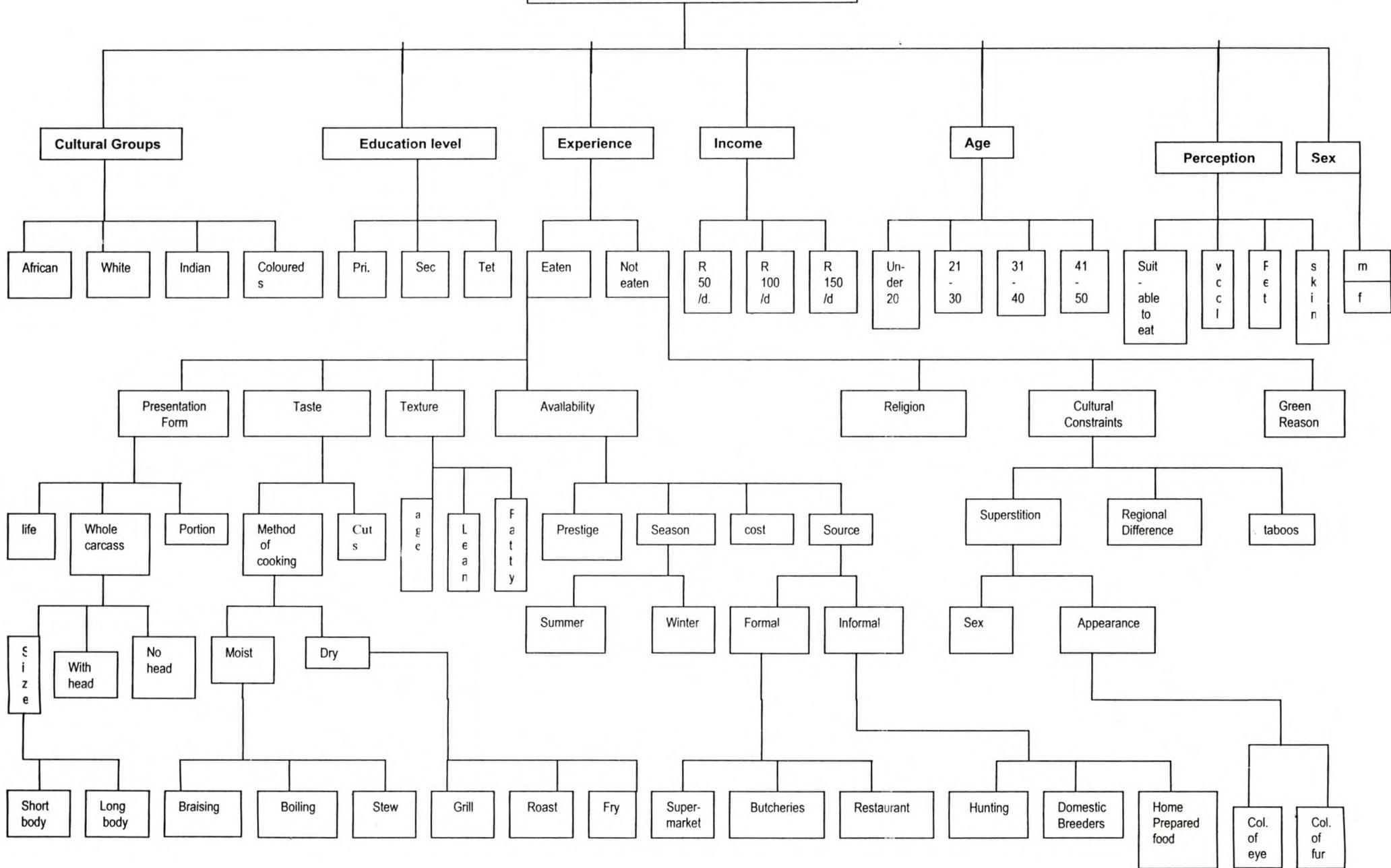
In order to increase the consumption of rabbit meat, an effort is needed to develop educational programmes regarding the benefits of rabbit meat. This can be achieved through planned marketing strategies and training programmes to familiarise people in the various aspects and multiple benefits of rabbit meat.

The consumer needs will have to be taken into consideration regarding differences in ethnic groups on the choice of rabbit meat. In this regard it is recommended that researchers should further investigate the perceptions about rabbit meat on other black ethnic groups present in this country.

ANNEXTURE 1

DENDROGRAM

CONSUMER ATTITUDE TOWARDS RABBIT MEAT



ANNEXURE 2

QUESTIONNAIRE



CONSUMER ATTITUDE TOWARDS RABBIT MEAT QUESTIONNAIRE

Thank you very much for your willingness to act as a respondent to this survey. Your name is never asked and there is no right or wrong answer to questions. Only your honest opinion is needed. Respondents are anonymous and questionnaires are treated as confidential. The researcher and interviewer undertake not to reveal any information that may lead to an individual respondent

The Survey is conducted to determine the potential for the marketing of rabbit meat in South Africa. This questionnaire is part of the study that involves a 9 week-fattening period of 60 rabbits at the University of Stellenbosch farm as well as conducting meat quality and chemical tests in the meat science laboratory. The aim of this research project is to provide valuable information to estimate the potential demand for rabbit meat in South Africa and will consequently benefit anyone interested in the business of rabbit meat processing/marketing.

This survey on rabbit meat preference will mainly focus on the following areas:

1. Experience on the consumption of meat and rabbit meat.
2. Perceptions about rabbit meat.
3. Cultural and religious constraints associated with consumption of rabbit meat.
4. Availability of rabbit meat in South Africa.
5. Presentation of rabbit meat for marketing.
6. Methods of cooking rabbit meat.

Thank you very much for your time and co-operation in this survey. Should you require any further information regarding this survey, you are more than welcome to contact Prof. Louw Hoffman at Tel (021) 8084747

.....
Pulane Nkhabutlane
RESEARCHER

1. Gender

Male	1	1
Female	2	2

2. With which population group do you associate yourself mostly?

Blacks	1	
Whites	2	
Coloureds	3	
Indians	4	
Other	5	3

3. In which of the following age groups do you fall?

- 20	1	
21 - 30	2	
31 - 40	3	
41 - 50	4	
51 +	5	4

4. What is your highest formal education?

Primary education	1	
Secondary education	2	
Tertiary education	3	5

5. What is your religion?

Christian	1	
Moslem	2	
Hindu	3	
Jewish	4	
Other	5	6

6. What is your total household's brute income, that is, income before deductions?

Per week	=	Per month	=	Per year	
0 - R 500	=	0 - R2 165	=	0 - R26 000	1
R 501 - R 600	=	R2 166 - R2 600	=	R26 001 - R31 200	2
R 601 - R 700	=	R2 601 - R3 033	=	R31 201 - R36 400	3
R 701 - R 800	=	R3 034 - R3 466	=	R36 401 - R41 600	4
R 801 - R 900	=	R3 467 - R3 900	=	R41 601 - R46 800	5
R 901 - R1 000	=	R3 901 - R4 333	=	R46 801 - R52 000	6
R1001 - R1 100	=	R4 334 - R4 763	=	R52 001 - R57 156	7
R1101 - R1 200	=	R4 764 - R5 160	=	R57 168 - R61 920	8
R1201 - R1 300	=	R5 161 - R5 629	=	R61 921 - R67 548	9
R1301 - R1 400	=	R5 630 - R6 062	=	R67 549 - R72 744	10

R1401 - R1 500	=	R6 063 - R6 495	=	R72 745 - R77 940	11	
R1501 - R1 600	=	R6 496 - R6 928	=	R77 941 - R83 136	12	
R1601 - R1 700	=	R6 929 - R7 361	=	R83 137 - R88 332	13	
R1701 +	=	R7 361 +	=	R88 332 +	14	8

7. What first comes to you mind when rabbit meat is mentioned?

7.1 8

7.2 and what else?..... 9

7.3 and what else?..... 10

8. What do you associate a rabbit with?

Meat	1	
Wool	2	
Pet	3	
Pelt	4	
Other	5	11

9. Would you describe rabbit meat as ...

Description	Don't Know	Yes	No	
Meat of an unclean animal?	1	2	3	12
Meat for the poor?	1	2	3	13
Meat for the rich?	1	2	3	14
Healthy meat?	1	2	3	15

10. According to your knowledge, are there any health benefits associated with rabbit meat?

Don't know	1	
No	2	
Yes	3	16

10.1 If yes, what are the health benefits associated with rabbit meat?

..... 17

.....

11. According to your knowledge is there any status associated with the consumption of rabbit meat?

No	1	
Yes	2	18

11.1 If yes, what is it?..... 19

11.2 Why is that?..... 20

12. Are there any superstitions associated with rabbit meat in your culture?

No	1	
Yes	2	31

12.1 If yes, what are they?

..... 32

..... 33

.....

13. According to your cultural beliefs, is there a taboo associated with the skin colour of a rabbit?

No	1	
Yes	2	24

13.1 If yes, what is it?

..... 35

.....

13.2. Do cultural constraints have more effect on the consumption of rabbit meat in the rural or urban areas?

Rural	1	
Urban	2	26

14. Does your religious belief forbid you to eat rabbit meat?

No	1	
Yes	2	27

14.1 If yes, why?

..... 28

15. If no, do you think rabbit meat can be served in a social gathering such as a religious gathering?

Yes	1	
No	2	29

15.1 If no, why?..... 30

.....

16. Do you eat meat?

Yes	1	
No	2	32

16.1 If no, why don't you eat meat?

Religion	1	33
Health	2	34
Against suffering of animals	3	35
Other.....	4	36

(Thank you for your cooperation)

17. Have you ever eaten rabbit meat?

Yes	1	
No	2	37

17.1 If no, why not?

17.2 If no, would you eat rabbit meat if it is available?

Yes	1	
No	2	30

(Thank you for your cooperation)

18. If yes, where did you eat the rabbit meat?

Restaurant	1	
Home	2	40

19. During which season of the year did you eat rabbit meat?

Summer	1	
Winter	2	41

20. If you have eaten rabbit meat before, did you like the meat?

No	1	
Yes	2	42

20.1 If yes, what did you like about the meat?

Flavour	1	
Texture	2	
Taste	3	
Colour	4	
Other	5	43

21. If no, what is it that you did not like about the meat?

..... 44

.....

22. How many times a year have you eaten rabbit meat?

N/A	1	
1 X per month	2	
2 X per month	3	
1 X in 6months	4	
1 X per year	5	45

23. How many times a year would you like to eat rabbit meat?

2X per month	1	
1 X per month	2	
2 X per year	3	
1 X per year	4	46

24. In what form would you prefer to get the raw rabbit meat?

Live	1	
Whole	2	
Portions	3	47

25. Would the colour of the rabbit's eyes influence your choice of rabbit meat?

No	1	
Yes	2	48

25.1 If yes, which colour of rabbit eyes would you prefer?

Pink	1	
Brown	2	49

25.2 Why do you prefer this particular colour of eyes?

50

26. If rabbit meat is presented as whole carcass, which of the following carcasses would you prefer?

Don't know	1	
Carcass without the head	2	
Carcass with head	3	51

26.1 If whole carcass, which type of body would you prefer most?

Short body	1	
Long body	2	52

27. Why do you prefer that part of the body?

53

28. If rabbit meat is sold in the form of portions are there any specific cuts you would prefer most?

No	1	
Yes	2	54

28.1 If yes, how would you rate your preference for the different cuts of rabbit meat?

Rabbit Cuts	Prefer less  Prefer most									
	1	2	3	4	5	6	7	8	9	
Legs	1	2	3	4	5	6	7	8	9	55
Chest	1	2	3	4	5	6	7	8	9	56
Shoulders	1	2	3	4	5	6	7	8	9	57
Ribs	1	2	3	4	5	6	7	8	9	58
Neck	1	2	3	4	5	6	7	8	9	59
Head	1	2	3	4	5	6	7	8	9	60

29. How would you prefer to purchase rabbit meat?

Fresh	1	
Frozen	2	
Canned	3	
Other	4	61

30. Why?.....

62

31. Would you give special attention to the packaging of rabbit meat?

No	1	
Yes	2	63

31.1 If yes, why?

64

31.2 How would you rate the following meat qualities while purchasing rabbit meat?

Meat qualities	Not at all  To a large extent									
	1	2	3	4	5	6	7	8	9	
Colour	1	2	3	4	5	6	7	8	9	65
Appearance	1	2	3	4	5	6	7	8	9	66
Smell	1	2	3	4	5	6	7	8	9	67
Weight	1	2	3	4	5	6	7	8	9	68

32. If no, why?

69

33. Is rabbit meat available in South Africa?

No	1	
Yes	2	70

33.1 If yes, how would you rate the availability of rabbit meat in the following places?

Places	Don't know	Not available  To a large extent									
		0	1	2	3	4	5	6	7	8	
Supermarkets	0	1	2	3	4	5	6	7	8	9	71
Restaurants	0	1	2	3	4	5	6	7	8	9	72
Butcheries	0	1	2	3	4	5	6	7	8	9	73
Hunting	0	1	2	3	4	5	6	7	8	9	74
Home breeder	0	1	2	3	4	5	6	7	8	9	75

33.2. According to your knowledge, is there a certain time of the year in which rabbit meat is commonly available?

No	1	
Yes	2	76

33.3 If yes which time of the year?

Summer	1	
Winter	2	

34. From which of the following places would you prefer to buy the rabbit meat?

Places	Yes	No	
Domestic breeders	1	2	78
Supermarkets	1	2	79
Restaurants	1	2	80
Hunters	1	2	81
Butcheries	1	2	82

35. Would the price play an important role in buying of rabbit meat?

Don't know	1	
No	2	
yes	3	83

35.1 If yes, are you prepared to pay more or less for rabbit meat than for chicken meat?

Less than for chicken meat	1	
More tan for chicken meat	2	84

36. Would you prefer to eat old or young rabbit?

Old	1	
Young	2	85

37. What is the reason for your choice?
.....

86

38. If you eat meat, do you prefer lean or fatty meat?

Lean	1	
Fatty	2	87

39. Why do you prefer that particular meat ?

88

40. If you have eaten rabbit meat before, how was it prepared?

Roasted	1	
Stewed	2	
Boiled	3	
Fried	4	89

41. According to your knowledge do you think there is any specific method of cooking suitable for cooking rabbit meat?

No	1	
Yes	2	90

41.1 How suitable are the following methods for cooking rabbit meat?

Methods of cooking	Least suitable  Most suitable								
	1	2	3	4	5	6	7	8	9
Braising	1	2	3	4	5	6	7	8	9
Boiling	1	2	3	4	5	6	7	8	9
Stewing	1	2	3	4	5	6	7	8	9
Grilling	1	2	3	4	5	6	7	8	9
Roasting	1	2	3	4	5	6	7	8	9
Frying	1	2	3	4	5	6	7	8	9

92
93
94
95
96
97

42. Is there any taste difference in different cuts of the rabbit carcass?

No	1
Yes	2

98
99

42.1 If yes, what is the difference?

43. If you eat rabbit meat, would you eat the offal?

No	1
Yes	2

100
101

43.1. If yes, how much would you prefer the following organs?

Offal's	Prefer less  Prefer most								
	1	2	3	4	5	6	7	8	9
Livers	1	2	3	4	5	6	7	8	9
Heart	1	2	3	4	5	6	7	8	9
Lungs	1	2	3	4	5	6	7	8	9
Kidneys	1	2	3	4	5	6	7	8	9
Gastrointestinal tract	1	2	3	4	5	6	7	8	9

102
103
104
105

44. Do you think the fur / skin colour of the rabbit can have an influence on the taste of rabbit meat?

No	1
Yes	2

106
107

44.1 If yes, how?.....

45. If you were to purchase the rabbit alive would you mind the colour of fur / skin?

No	1
Yes	2

108
109

45.1 If yes which colour do you prefer?

.....

45.2 Why do you prefer this particular colour?

.....

110

Thank you for your cooperation